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THE STRUCTURE
OF THE
COMPUTER INDUSTRY

by

Roger L. McDonald III

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Thesis Advisor: William J. Haga

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This study updates the assessment of the industrial and market structure of the computer manufacturing and software development industries. It describes the structure of these industries in terms of market concentration, barriers to entry, organizational strategies, and legal issues. It also examines the impact of the PC revolution on the market structure of computer manufacturing and software development. Additionally, it describes and analyzes events in computer manufacturing and software development since the late 1980s in terms of alliances, mergers, and market concentration, as the computer industry shakes out marginal participants and re-aligns market power and technology rights of major players. The study forecasts a ten year scenario for the evolution of the computer manufacturing and software development industries by extrapolating from recent events and from histories of similar mature industries.

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The Structure of the Computer Industry

by

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ABSTRACT

This study updates the assessment of the industrial and market structure of the computer manufacturing and software development industries. It describes the structure of these industries in terms of market concentration, barriers to entry, organizational strategies, and legal issues. It also examines the impact of the PC revolution on the market structure of computer manufacturing and software development. Additionally, it describes and analyzes events in computer manufacturing and software development since the late 1980s in terms of alliances, mergers, and market concentration, as the computer industry shakes out marginal participants and re-aligns the market power and technology rights of major players. The study forecasts a ten year scenario for the evolution of the computer manufacturing and software development industries by extrapolating from recent events and from histories of similar mature industries.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The computer industry is one of the most complex, turbulent, and interesting industries in the world today. Few industries have the unique personalities, revolutionary forces, and love-hate relationships that prevail in the computer industry. While most advances in the industry have occurred in the past 25 years, the computer industry has dramatically influenced many other industries, changing the entire nature of business in some.

In order to assess the significance of the computer industry, its impact on the world, and forecast future trends, it is useful to examine the market structure of the industry. Alan K. McAdams' framework for analyzing American industries provides a useful model for this study (McAdams, 1990). Using McAdams' model as a basis, this study reviews the history of the computer industry and identifies the complexities of today's maturing industry. Unlike past studies, this update analyzes in detail, the immediate and long-term impacts of the PC revolution. The study also reveals the recent power alignments among the major players in the industry and forecasts how these ties and other shaping forces will mold the computer industry of the future.

While the computer industry consists of several segments, this study focuses on the computer manufacturing and software

development industries. Following this introduction, the study is organized into seven chapters. The first two chapters analyze the market concentration of the computer manufacturing and software development industries. Chapter IV views the historical barriers to entry in the computer industry and examines how these barriers have changed, as the industry approaches maturity. Chapter V examines in detail, the PC revolution's impact on the computer industry and the lives and ideas of America as a whole. Chapter VI views the legal aspects of the computer industry to analyze the government's role in shaping the industry. Chapter VII describes the recent strategies among major players within the industry and analyzes the motivations and implications of these strategies. The final chapter forecasts the evolution of the computer manufacturing and software development industries using trends from recent events and from the histories of similar, more mature industries, such as the auto manufacturing industry.

II. COMPUTER MANUFACTURING MARKET CONCENTRATION

A. Methodology

This study of the market concentration of the computer manufacturing industry begins with the introduction of the minicomputer by Digital Equipment Company (DEC) in 1957 (Brock, 1975, p. 56). The study first views the computer industry as a whole and describes the market shares of the top eight firms in the industry from 1957 to 1968, and the top ten firms from 1970 to 1979. To analyze the 1980s, the study divides the industry into its major market segments: mainframes, minicomputers, and microcomputers. The market shares of each segment are described using constant 1990 dollars for the top ten firms in each segment.

In analyzing the industry by market share, it is important to define what activities and products constitute market share. The definition of market share in the computer manufacturing industry in the 1960s and 1970s has been a source of controversy due to the antitrust suits filed against IBM and the antitrust significance of market shares (McAdams, 1990 p. 167). Up to 1980, this study will use the Department of Justice's definition of " a mainframe or general purpose market for full-line general purpose machines, excluding companies that provided only software or specialized

computers." (McAdams, 1990, p. 167) After 1980, the study will use Datamation's classification of mainframe, minicomputer, and microcomputer market segments as published in the annual Datamation 100.

B. The Computer Manufacturing Industry in the 1960s

1. Background

In the late 1950s and 1960s, the computer manufacturing industry converted from the first generation of computers, consisting of vacuum tube machines, to the second generation of transistor systems. This generation of transistor computers lasted from approximately 1959 to 1965, and expanded the market from just over one billion dollars worth of equipment installed in 1959, to over six billion dollars installed in 1965, in current year dollars. (Brock, 1975, p. 15)

The third generation of computers, based on integrated circuits, was introduced in 1965. Most noteworthy in early integrated circuit technology was IBM's System 360, initially delivered in 1965. This successful system accounted for nearly 50 percent of the total value of IBM computers installed in 1965. (Brock, 1975, pp. 14-15)

While IBM focused on central processing units (CPUs) in the late 1960s, a number of other companies took advantage of improvements in technology to compete with IBM's peripheral devices, establishing device independent "plug compatibles"

(Brock, 1975, p. 14-16). As technological improvements in the computer industry flourished in the 1960s, the market structure stabilized due mainly to barriers to entry in the industry, such as economies of scale, software lock-in, and bundling. (McAdams, 1982, p. 256)

2. Industry Structure in the 1960s

In the late 1950s and 1960s, the computer manufacturing industry included only seven or eight companies and showed no new entry after 1960. IBM maintained a steady market share averaging 71%, with a high in 1957 of 79% and a low in 1965 of 65%. A major reason for IBM's early dominance was its ability to successfully transfer the technology developed for military contracts into commercial products (McAdams, 1990, pp. 166-167). Figure 1 shows the market share trends of the top three computer manufacturing companies in the 1960s. IBM's major competition during this period was Sperry Rand, whose market share averaged 13%. Burroughs had its highest average market share during this period, but steadily declined in market share through the 1960s. Table 1 through Table 12 depict the annual ranks and market share percentages of the eight largest companies in the industry during this period. Due mainly to IBM's dominance, the average market share for five of the eight firms in Table 1 through 12 was less than 3% during the period.

THE 1960s COMPUTER INDUSTRY
THE TOP THREE COMPANIES

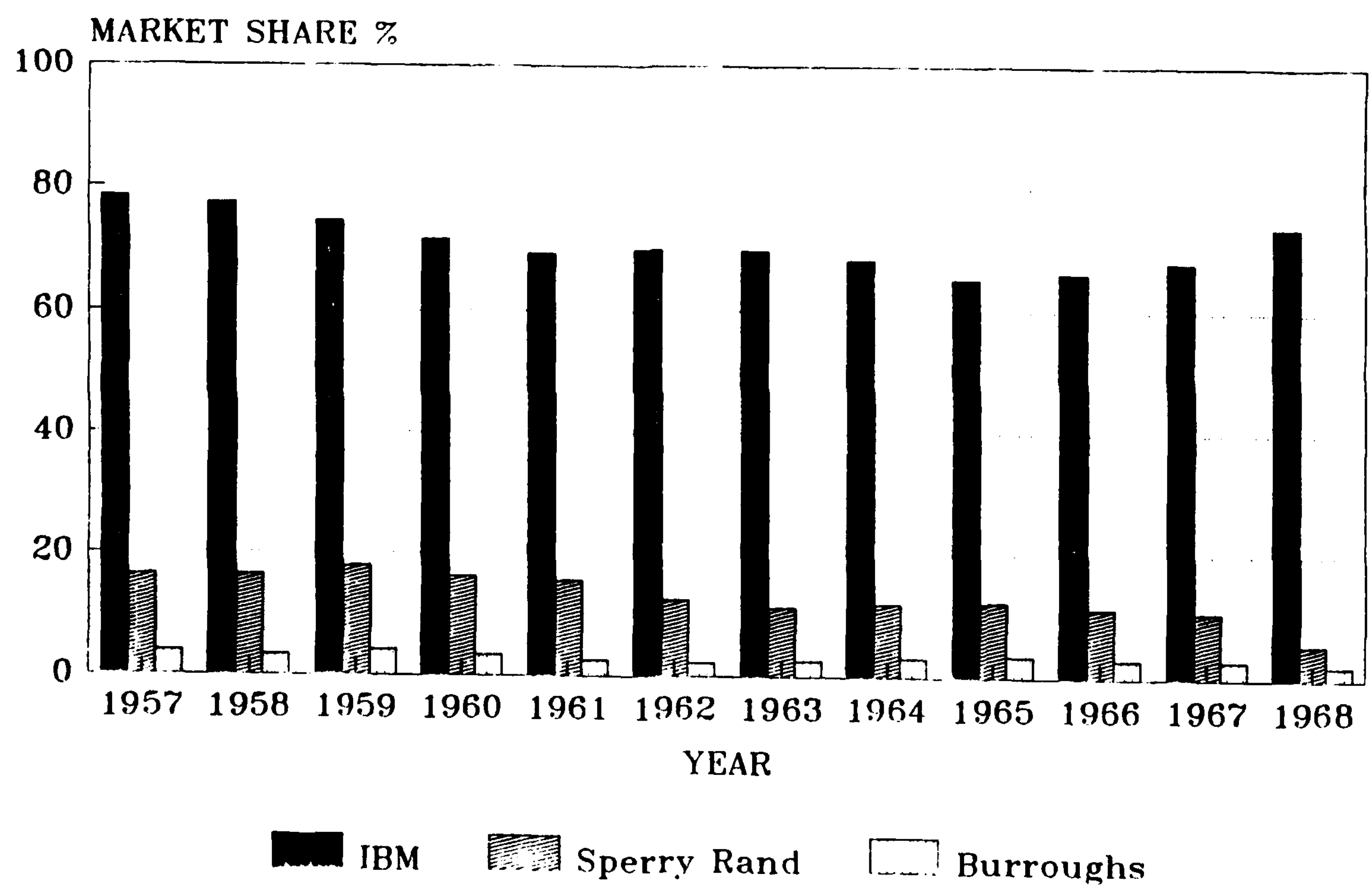

FIGURE 1 (Source: TABLES 1-12)

C. The Computer Manufacturing Industry in the 1970s

1. Background

Fourth generation computers were introduced between 1971 and 1973. The primary change was a movement from integrated circuits to large scale integration, where a number of complete circuits are packaged on a single silicon chip (Brock, 1975, p. 20). During the late 1960s and early 1970s, the industry also saw the emergence of minicomputers as a viable alternative to traditional mainframe applications. While still insignificant competitors to mainframe systems, minicomputers began to grow in importance and use in the 1970s, offering more computing power per dollar.

2. Industry Structure in the 1970s

IBM's dominance in the 1960s declined by approximately 30 percent from 1970 to 1979, yet it clearly remained the industry leader. Figure 2 shows the market shares of the top three computer manufacturing companies in the 1970s. While IBM led the industry with an average market share of over 50% during the period, Burroughs and Honeywell closed out the top three, both averaging over 5%.

Table 13 through Table 21 depict the annual ranks and market shares of the top ten firms in the industry in the 1970s. Unlike the 1960s, the 1970s revealed a more

THE 1970s COMPUTER INDUSTRY
THE THREE COMPANIES
(1972 values estimated)

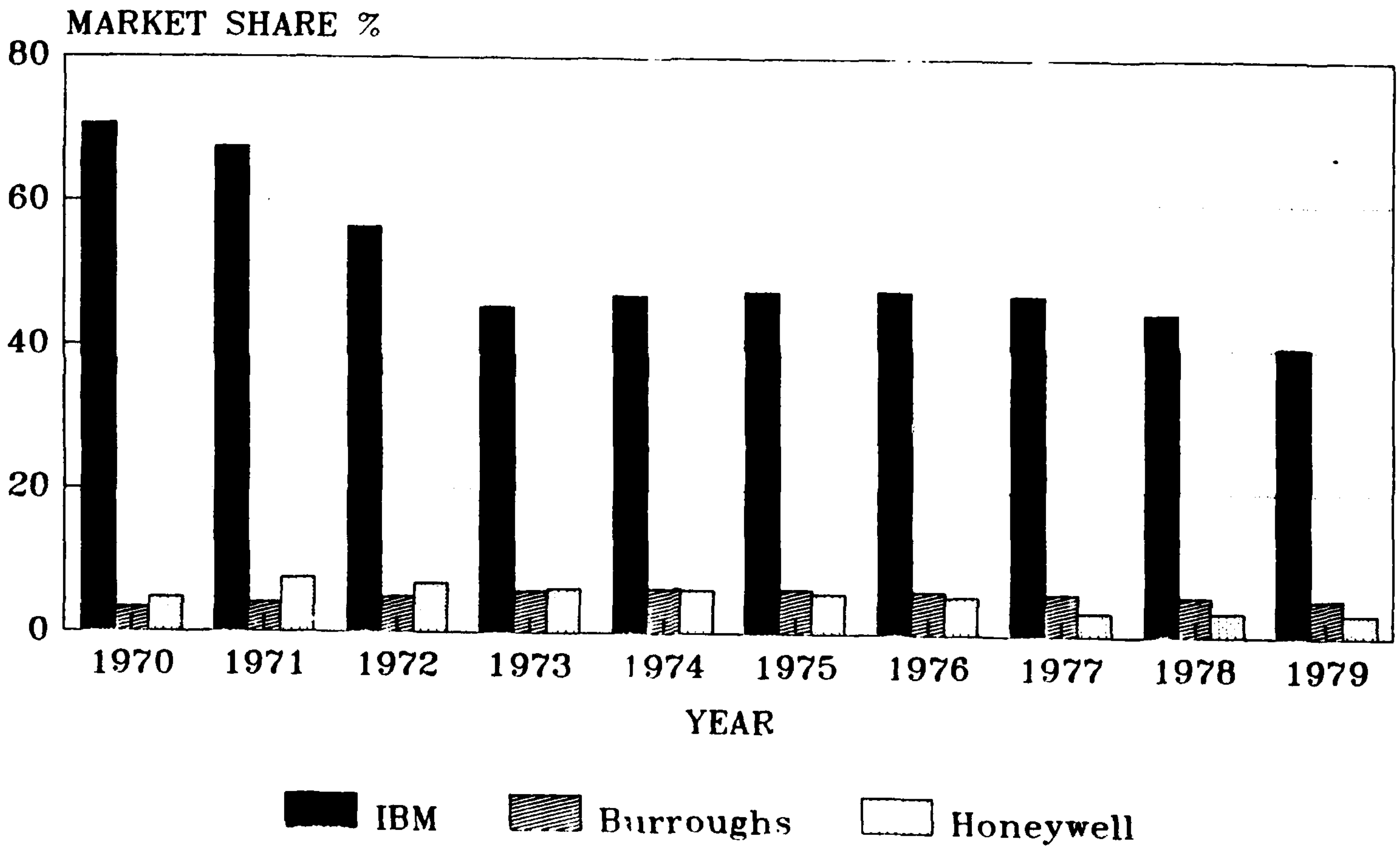

FIGURE 2 (Source: TABLES 13-21)

competitive market and a more even distribution of market share among the top ten companies, with the majority of companies controlling more than 3% of the market. This trend shows IBM's loss of total dominance. More importantly, it shows how the emerging diversity of the industry opened the market for companies that effectively applied the decade's rapidly growing technology.

D. The Computer Manufacturing Industry in the 1980s

1. Background

In the 1980s, clear market segments emerged and the industry's total revenues increased from 55.6 billion in 1980 to 278.5 billion in 1990, in current year dollars. Table 22 depicts the market segments during the 1980s in billions of dollars for mainframes, minicomputers, and microcomputers, as well as the total information systems (IS) revenues.

In order to better determine trends in the IS industry, the data in Table 22 is converted to constant 1990 dollars using the Consumer Price Index. The values are given in Table 23. Figure 3 is a graphical portrayal of the market segments in constant 1990 dollars, showing the industry trends in the 1980s. While the mainframe and minicomputer markets remained relatively stable from 1979 to 1983, the almost non-existent microcomputer market grew from a mere $.75 billion in 1979 to $10 billion in 1983. Each segment continued to grow during the mid 1980s, due mainly to the expansion of automated

COMPUTER MANUFACTURING MARKETS
IN CONSTANT 1990 DOLLARS

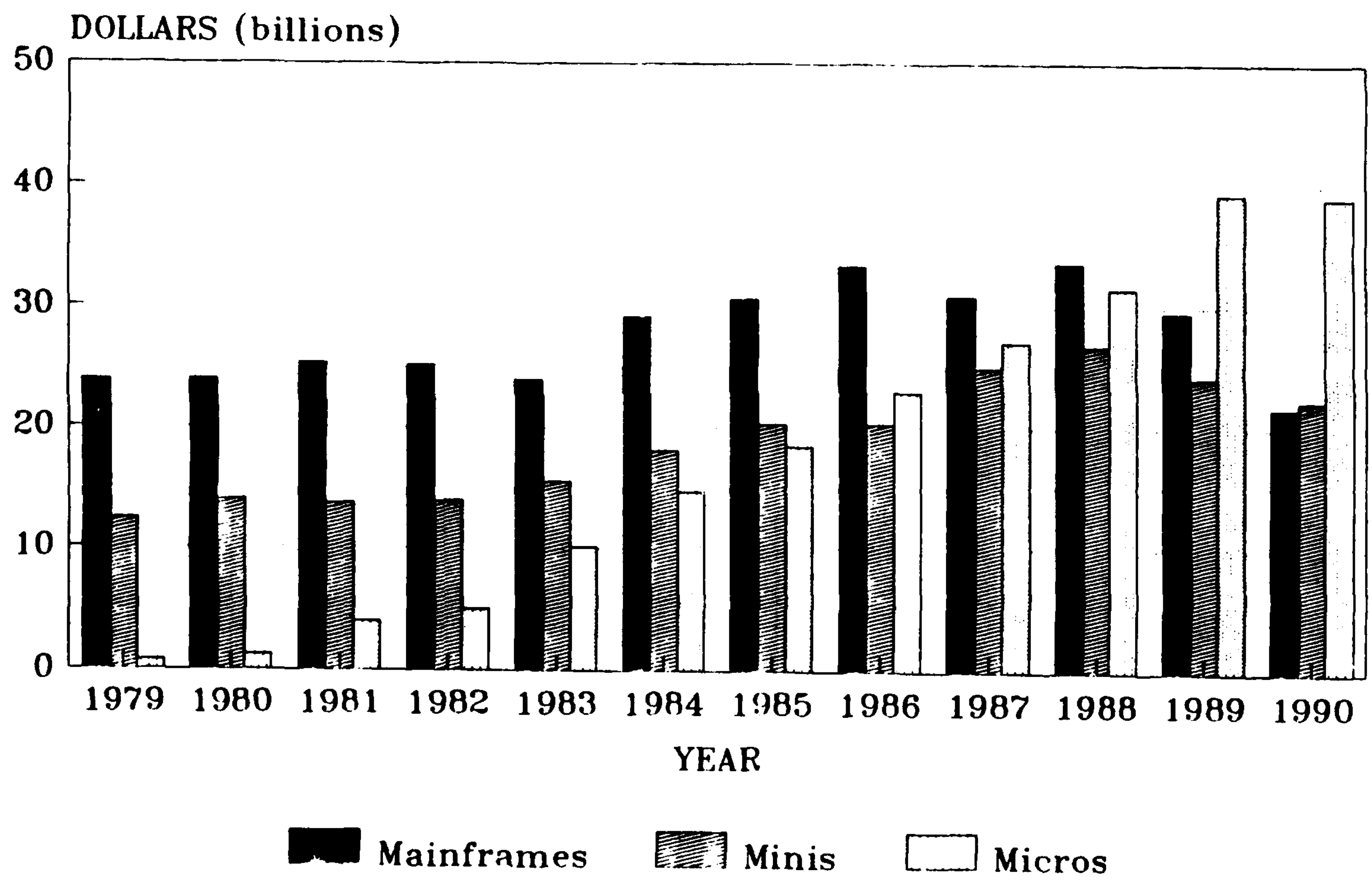

FIGURE 3 (Source: TABLE 23)

systems throughout virtually every industry. During the late 1980s, the mainframe market began to decline, ending in 1990 at 21.7 billion dollars, its lowest point in the decade. The minicomputer market saw a similar trend, peaking in 1988 at 26.8 billion, then declining to 22.3 billion in 1990. The microcomputer market however, continued to rise during the late 1980s, ending in 1990 at 39 billion dollars, over 30 times the revenues of 1980. The reasons for the microcomputer's increasing dominance of the industry is discussed in detail in another chapter.

After describing the trends of the major segments of the computer manufacturing market, this study looks at the major companies and trends in each market segment during the 1980s.

2. The Mainframe Market Structure in the 1980s

Although the mainframe market segment declined during the 1980s, mainframe systems continue to be vital to organizations that require computing power. While IBM dominated the mainframe market in the 1980s, its market share declined from a high of 78% in 1982, to a low of 40% in 1988. IBM's market share ended the decade at 49%. Figure 4 shows the market shares of the top three mainframe manufacturers in the 1980s. Burroughs, which merged with Sperry in the mid 1980s to form Unisys, averaged 6% of the mainframe market in

MAINFRAME MARKET SHARES
THE TOP THREE COMPANIES

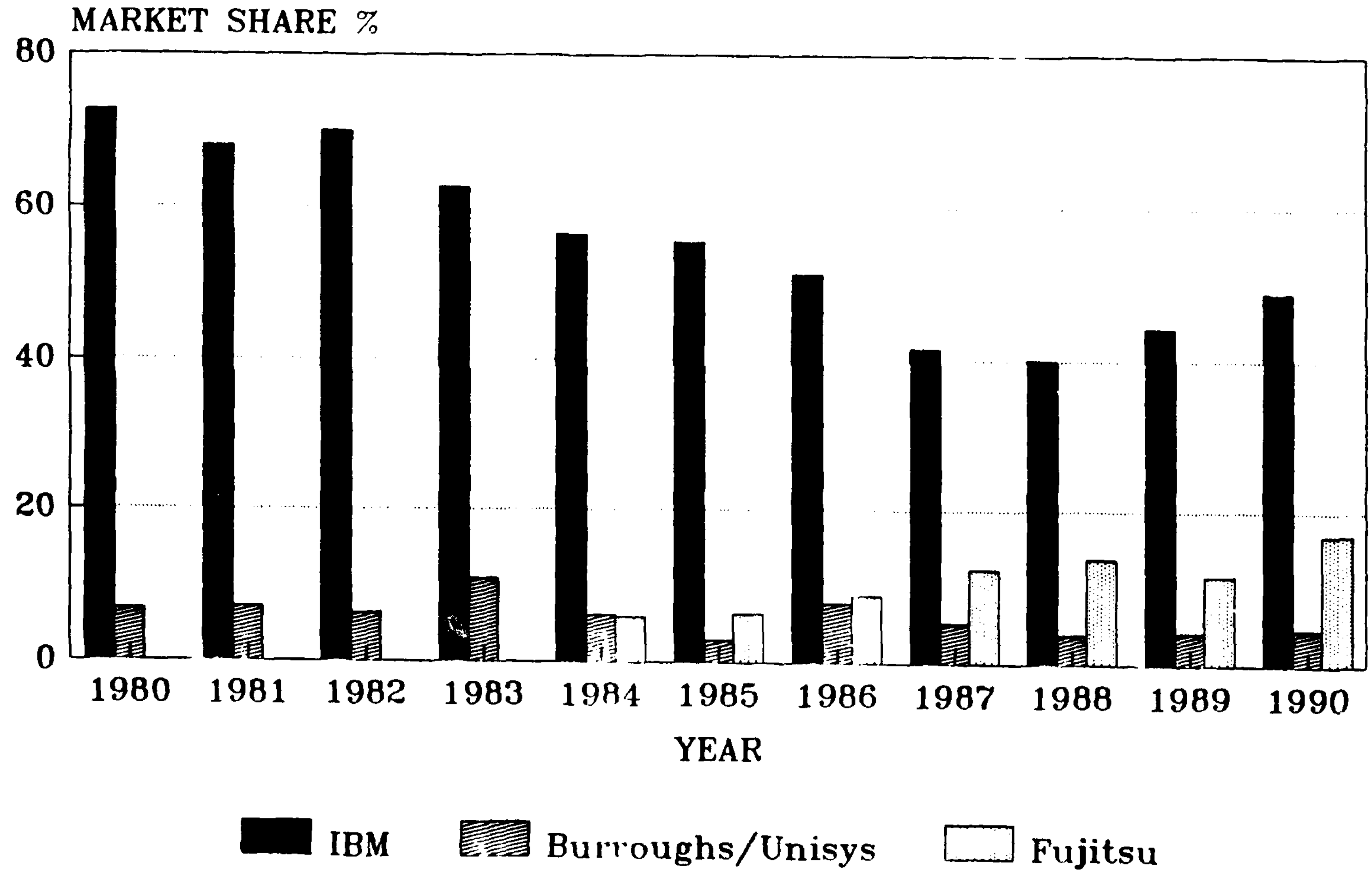

FIGURE 4 (Source: TABLES 24-24)

the 1980s and was IBM's major competition in the early 1980s. In the mid 1980s, Fujitsu gained market share to become IBM's major competitor in the late 1980s.

Table 24 through Table 34 depict the annual ranks and market shares of the top ten mainframe manufacturers in the 1980s. As with the industry in the 1970s, the 1980s saw a progressively more even distribution in market share. It also saw the bulk of IBM's competition coming from foreign companies, with Fujitsu, Hitachi and NEC, each controlling over 12% of the mainframe market in 1990. The rest of the companies in the top ten averaged less than 5% of the mainframe market throughout the 1980s.

3. The Minicomputer Market Structure in the 1980s

The minicomputer market segment declined in the 1980s, like the mainframe's. However, the use of minicomputers in distributed computing applications, lessened the magnitude of decline compared to the mainframe market. Figure 5 shows the market shares of the top three minicomputer manufacturers in the 1980s. Digital Equipment Corporation (DEC) led the minicomputer market share in the early 1980s. However, IBM entered the minicomputer market in 1982 and finally took the lead for the rest of the decade in 1984, averaging over 20% of the minicomputer market share. Hewlett Packard's relatively constant minicomputer market share closed out the top three minicomputer manufacturers. Table 35 through Table 45 depict

MINICOMPUTER MARKET SHARES
THE TOP THREE COMPANIES

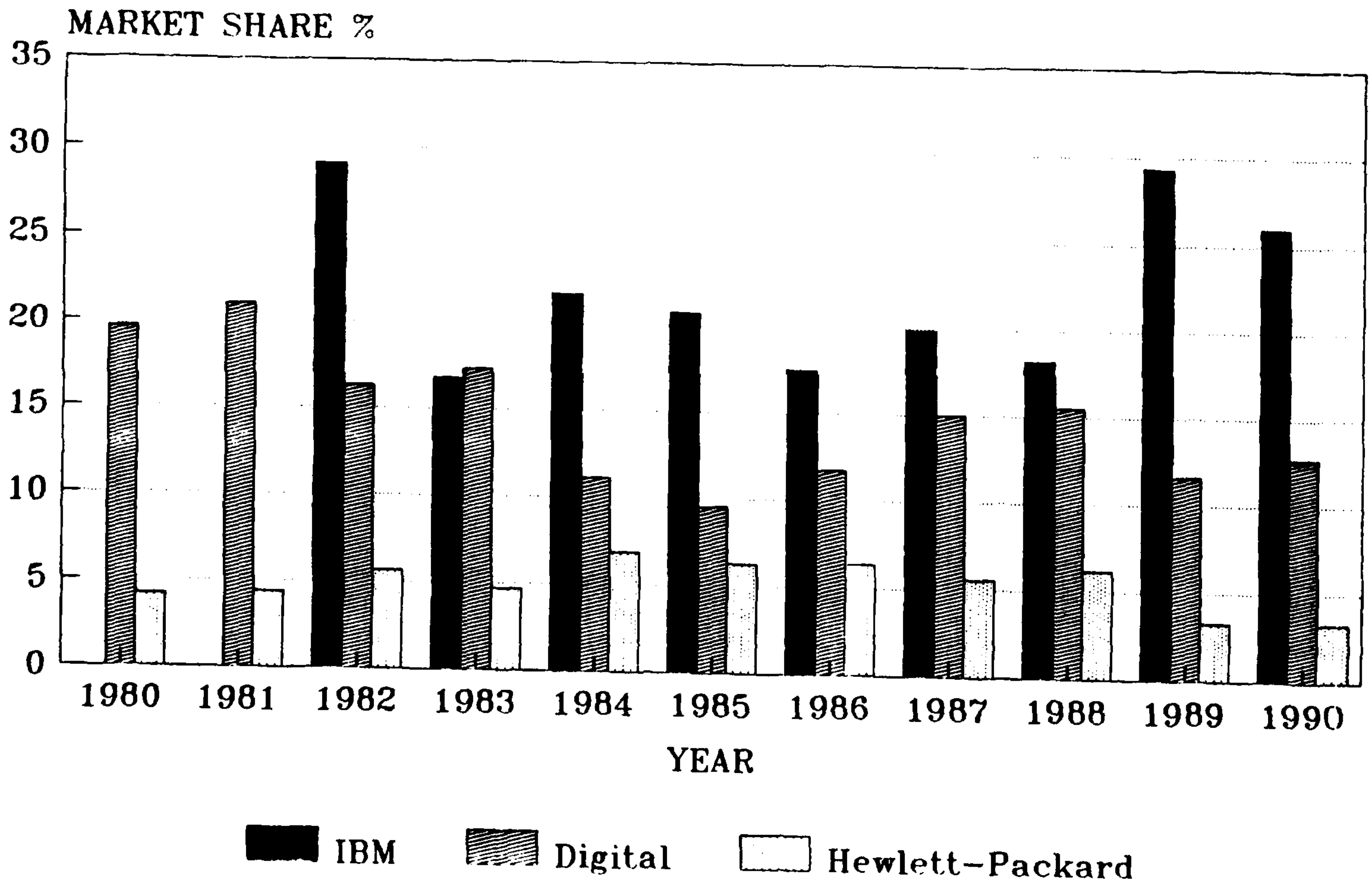

FIGURE 5 (Source: TABLES 35-45)

the annual ranks and market shares of the top ten minicomputer manufacturers in the 1980s, showing an even more competitive market than that of the mainframe. As with the mainframe market, the minicomputer market also saw the same trend of increased foreign control, with Fujitsu, NEC and Toshiba each controlling over 5% of the market in 1990.

4. The Microcomputer Market Structure in the 1980s

The microcomputer market segment played an increasingly integral part of the total IS revenue of the 1980s. The expanding number of microcomputer users in business and for personal use is one reason for the increased strength. Another, perhaps more important reason, was the microcomputer's ability to perform more complex applications due to its increased computing power. The end result of this added computing power was a microcomputer price to performance ratio offering 50 times the value of mainframe systems.

IBM also led in the microcomputer market share in the 1980s with an average over 25%, despite the dismal introduction of PS2. Figure 6 shows the market shares of the top three microcomputer manufacturers, with Apple averaging 12% and Compaq averaging 6% to close out the top three manufacturers. Table 46 through Table 56 depict the annual ranks and market shares of the top ten microcomputer manufacturers. This was the most competitive computer

MICROCOMPUTER MARKET SHARES
THE TOP THREE COMPANIES

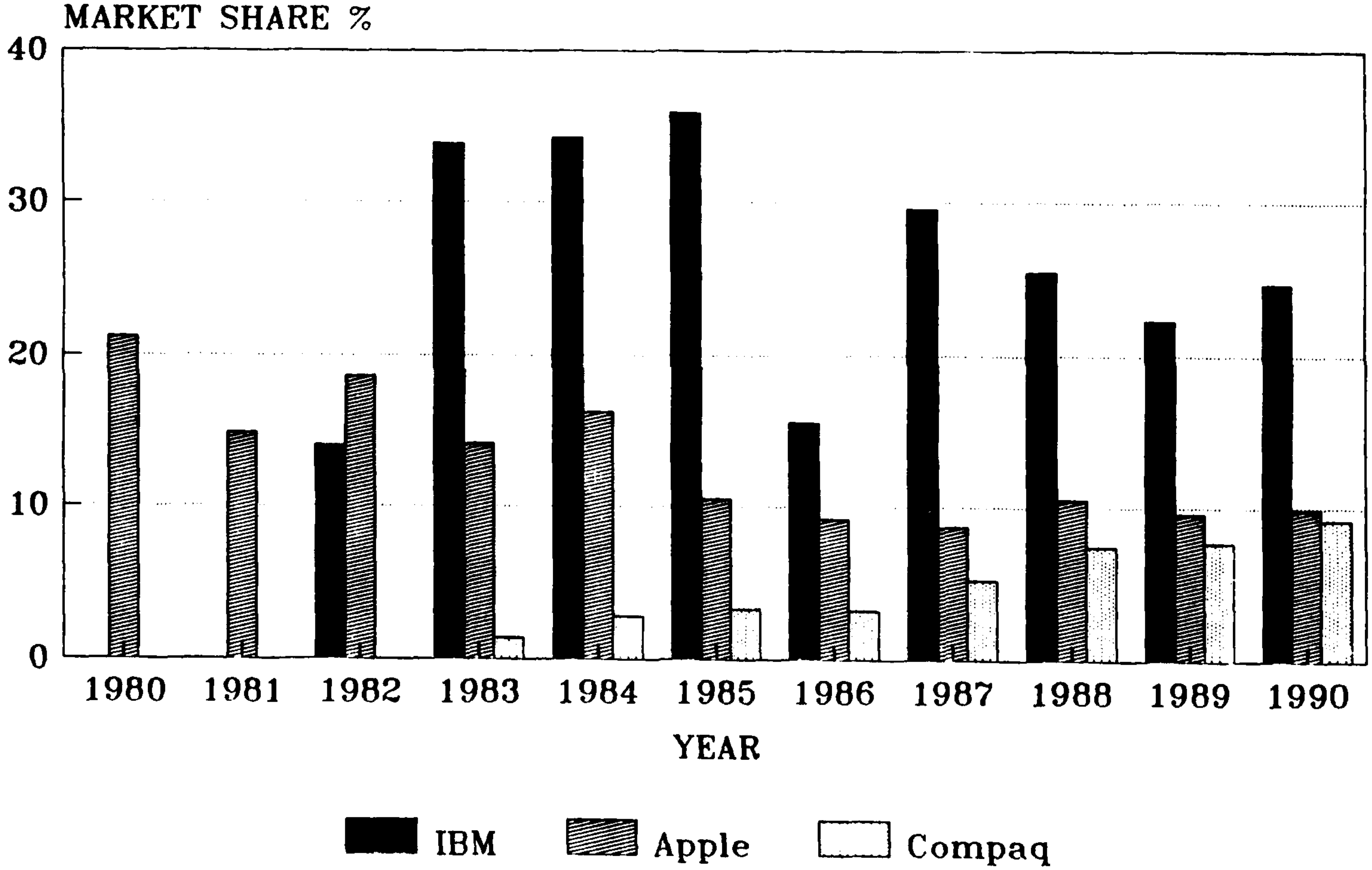

FIGURE 6 (Source: TABLES 46-56)

manufacturing market segment in the 1980s. As with the other market segments, the microcomputer market also saw increased foreign control. Four foreign manufacturers are included in the top ten and they control a combined 29% of the market.

III. SOFTWARE DEVELOPMENT MARKET CONCENTRATION

A. Methodology

This study of market concentration in the software development industry uses Datamation's first annual survey of the worldwide computer industry in June 1976 as a starting point. Since Datamation's survey does not distinguish between the software and services industry and the software development industry until 1984, this chapter looks at software and services from 1975 to 1983, then views software development from 1984 to the present. We will initially look at software and service's input to the total IS revenue, then analyze the market share percentage of the top ten firms in the software and services industry from 1975 to 1983. We will then view software development's input to the total IS revenue from 1984 to the present, and again look at the market share percentage of the top ten firms in the software development industry.

B. The Software and Services Industry, 1975 to 1983

1. Background

The software and services industry corresponds to Datamation's definition of software and services: "software products, plus all types of time sales, maintenance, training

and customer assistance provided for a fee." (Rothenbuecher, June 1976, p. 49)

Prior to 1975, the software and services industry saw the traditional presence of computer manufacturers in the market. The bulk of the software was in the form of systems software, provided with the hardware and necessary to run the computer system. Additionally, manufacturers provided limited applications software designed for specific requirements of large customers, while some also designed custom software as part of their time-sharing services. A general practice during these early years of software and services was that of "bundling," or including systems software in the price of the hardware, instead of invoicing it separately. A significant United States Department of Justice decision in 1969 changed this practice. It required IBM to invoice its hardware and software separately, increasing competition in the industry. (ICCP, 1985, pp. 55-56)

Table 57 shows software and service's dollar input to the total IS revenue and its percentage of the IS market form 1975 to 1983. Software and services averaged over 20% of the IS revenue during this period. To better analyze software and service's input to the total IS revenue, the dollar figures of Table 57 were converted to constant 1990 dollars using the Consumer Price Index. These values are provided in Table 58. Figure 7 is a graphical portrayal of those figures, showing the trends of the software and services industry form 1975 to

SOFTWARE AND SERVICES MARKET
IN CONSTANT 1990 DOLLARS

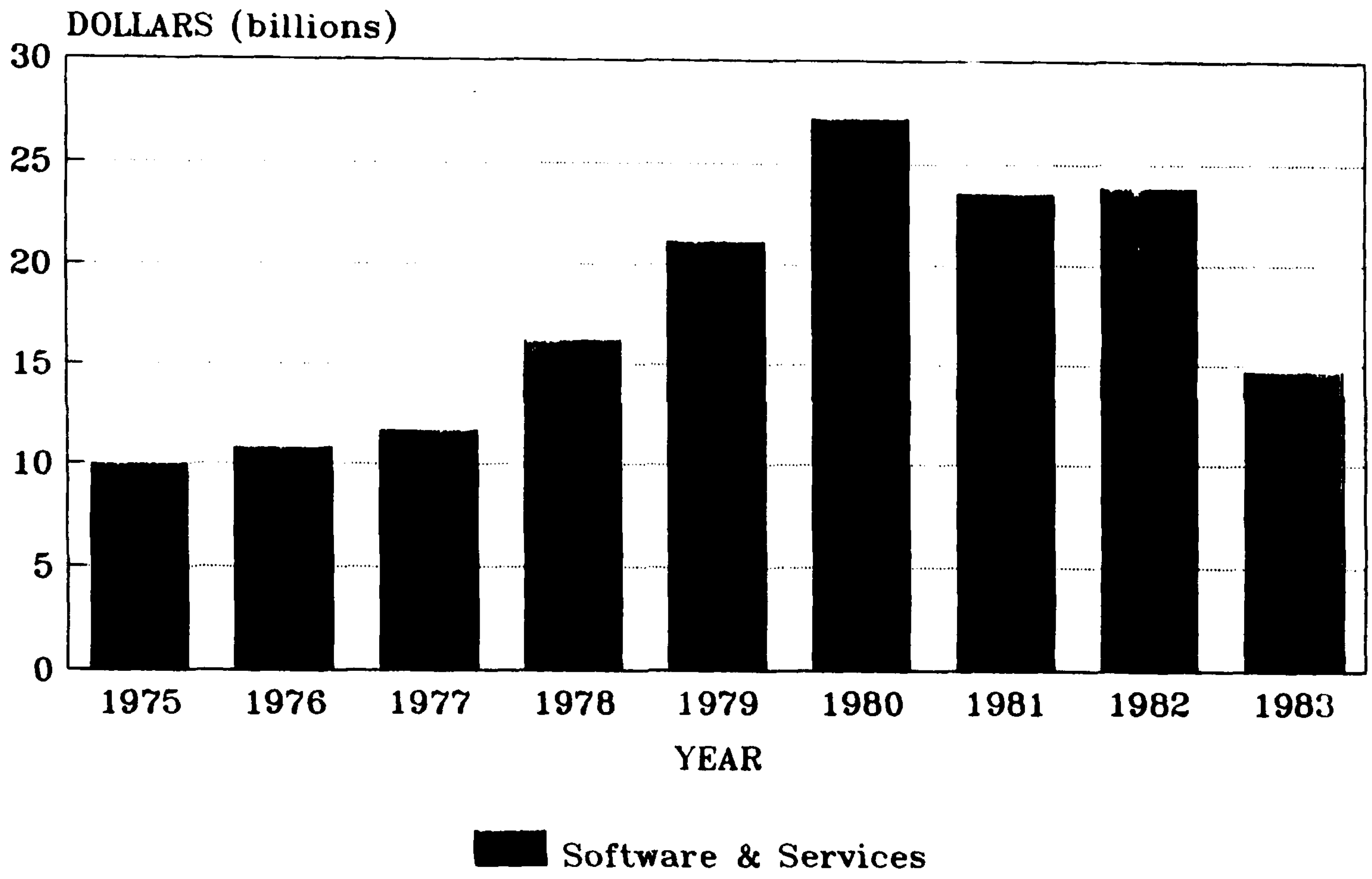

FIGURE 7 (Source: TABLE 58)

1983. While the mid 1970s showed a relatively constant input to the total IS revenue, the late 1970s and early 1980s depicts the accelerated growth of the software and services industry. One major reason for this growth was the rise of the microcomputer during the period and the corresponding move of established software concerns into the micro software field (Archbold, June 1982, pp. 114-119). The decline of the software and services industry in 1983 is due mainly to decreasing use of remote computer services, which were replaced by the microcomputer. The software market in 1983, on the other hand, remained strong. Mainframe software companies showed the largest gains, while microcomputer software companies continued to exhibit strength, due to the rising demand for microcomputers (Archbold, June 1, 1984,pp. 52-57).

2. The Top Software and Services Firms, 1975 to 1983

Figure 8 shows the market share percentages of the top three companies in the software and services industry from 1975 to 1983. IBM led the industry averaging 27% of the market share during the period. Control Data, averaging over 8%, was IBM's primary competition, while NCR, averaging over 6%, closed out the top three during the period. Table 59 through Table 67 depict the annual ranks and market shares of the top ten firms in the software and services industry from 1975 to 1983. The figures show a progressively more

SOFTWARE & SERVICES MARKET SHARES
THE TOP THREE COMPANIES

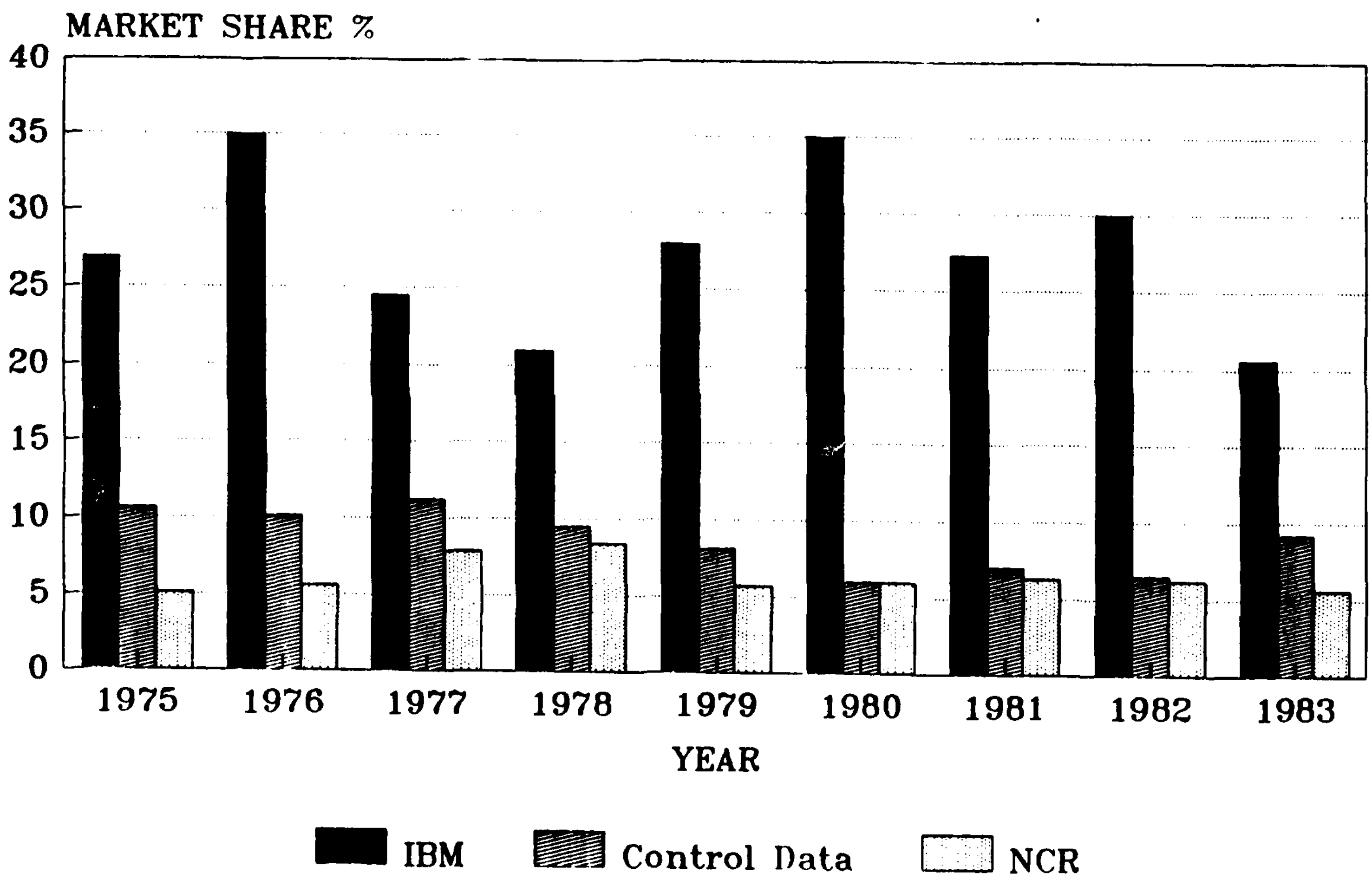

FIGURE 8 (Source: TABLES 59-67)

competitive market, with eight of the top ten companies each controlling over 5% of the market in 1983. This period also saw the emergence of pure software and service companies. Three of the top ten companies, Automatic Data, Computer Sciences, and Electronic Data provided only software and services.

C. The Software Development Industry, 1984 to 1990

1. Background

The developments throughout the computer manufacturing industry in the mid 1980s introduced new forces that affected the software strategies of both hardware manufacturers and pure software companies. The major forces were:

- The shift to distributed, integrated computing.
- The slowdown in the overall growth of computer hardware markets.
- Increasing national and international competition in those markets and pursuit of competitive strategies by creating 'captive' hardware manufacturers even in their own special reserve of systems software. (ICCP, 1985, p. 56)

These forces resulted in software strategies that focused on four fronts:

- Work on systems software, incorporating the principles of distributed and integrated processing.
- Development of "firmware," software designed to be embedded in hardware systems, enabling computer manufacturers to design computers that are only compatible with systems software they develop or choose.
- Development of an applications software offensive.

* Establishing the policy of turnkey systems, which are complete hardware and software systems for a specific purpose. These systems are maintained and marketed as a single package, with the intent of simplifying the user's involvement in software engineering and allowing the user to deal with only one computer supplier. (ICCP, 1985, p. 56-58)

Table 68 depicts software's dollar input to the total IS revenue and its percentage of the IS market from 1984 to 1990, showing a constant rise in percentage from 6.2% in 1984 to 11.9% in 1990. To better analyze software's input to the total IS revenue, the dollar amounts of Table 68 are again converted to constant 1990 dollars, resulting in the values of Table 69. Figure 9 is a graphical portrayal of these values, showing the market share trends of the software development industry form 1984 to the present. The figures again show the continual rise of the industry from just over 10 billion in 1984 to over 33 billion in 1990. While the mid 1980s saw a slight rise in the industry, with very few pure software companies, the industry took off in the late 1980s. The software industry revenues of 1987 outgrew all technology segments, spurting 29.6% to 17 billion (Runyan, June 15, 1988, pp. 155-166).

The industry saw comparable increases in 1988 and 1989, and a sharp increase to 33.1 billion in 1990, as the software industry continued to become more international (Poppel, June 15, 1990, pp. 194-195).

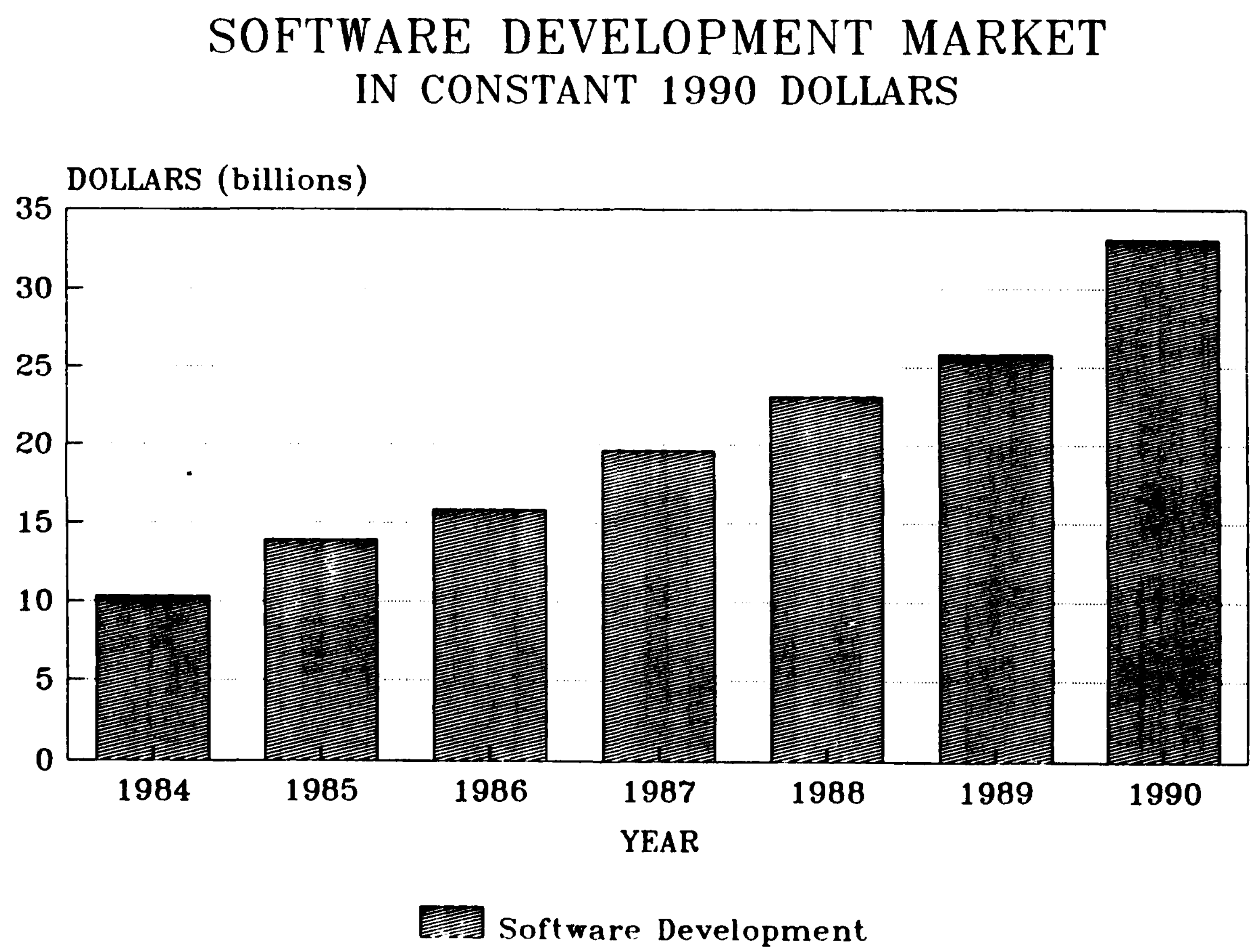

FIGURE 9 (Source: TABLE 69)

2. **The Top Software Development Firms, 1984 to 1990**

Figure 10 shows the market share percentages of the top three companies in the software development industry from 1984 to 1990. While IBM showed a continual decline, it clearly led the industry in the 1980s, averaging over 37% of the market share. Burroughs, a firm that merged with Sperry in 1985 to form Unisys, and NEC were IBM's primary competition during the period, both averaging about a 4% share of the market. Table 70 through Table 76 depict the ranks and market shares of the top ten firms in the software development industry from 1984 to 1990, with Fujitsu becoming IBM's primary competition in the late 1980s. Like the computer manufacturing industry, the software development industry saw an increasing number of foreign companies. In 1990, four foreign companies were in the top ten, controlling a combined 16% of the market. Pure software companies also emerged as powers in the late 1980s, with four of the top ten companies in 1990 providing only software.

D. **The Pure Software Companies**

Pure software companies in the late 1980s and early 1990s realized the largest growth in the software development industry. The one hundred companies that comprise the Softletter 100 achieved average sales increases of 46% in 1988 and 56% in 1989 (Softletter 100, 1990, p.1). Despite the start of the recession in 1990, Datamation's survey of

SOFTWARE DEVELOPMENT MARKET SHARES
THE TOP THREE COMPANIES

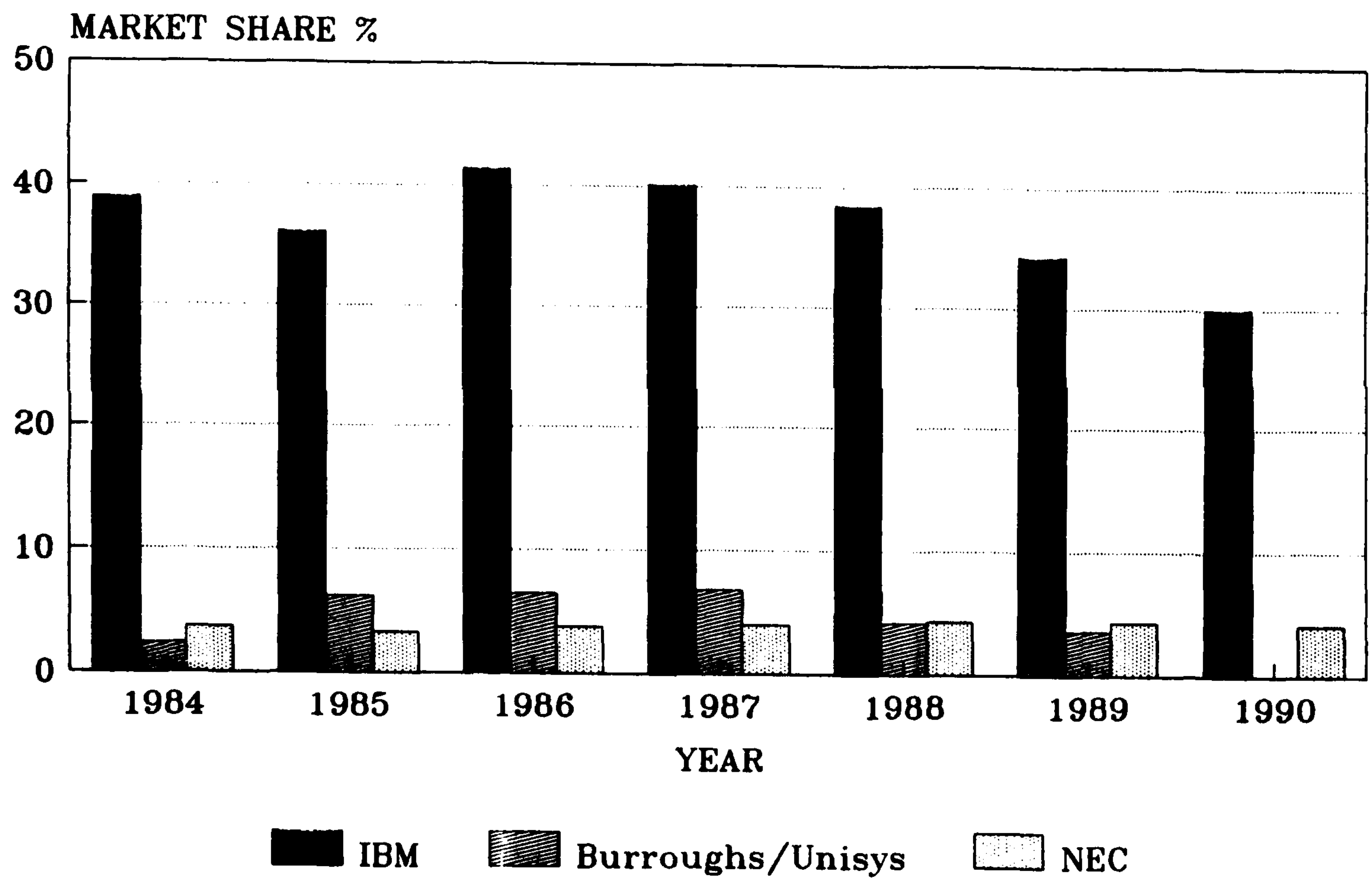

FIGURE 10 (Source: TABLES 70-76)

Software's Big 50 saw an increase of 32% in 1990 (Hamilton, October 1991, pp. 58-62). The reasons for this phenomenal growth were twofold. The increased power per dollar of personal computers and workstations allows independent software firms to capitalize on the increased capabilities, offering more powerful application software. Another reason for the success of independent software firms is their evolutionary approach to software development, offering users an upgrade of existing product lines instead of a revolutionary change (Hamilton, October 1991, pp. 58-62). This type of approach allows firms to take advantage of technological advances to meet increasing demands for interoperability and ease of use. Through upgrades of existing software, the firms can drastically cut the cost and development time for the new software.

During 1989 and 1990 independent software firms contributed over 40% of the total software development revenue. Table 77 shows the top ten independent software firms by market share percentage. Most noteworthy of these pure software companies was Microsoft. Their development and maintenance of the MS-DOS IBM PC operating system throughout the decade, and the massive sales of Windows 3.0 in 1990, made Microsoft one of the fastest growing companies in any industry. Computer Associates, though not as popular as Microsoft, stayed close to the industry giant in market share in 1990. Oracle and Lotus also proved themselves, each

controlling over 5% of the independent software market share in 1989 and 1990. The market share percentages of the other companies in the top ten exhibit the growth of the independent software company in a day when hardware companies are restructuring and downsizing. With this kind of growth, independent software firms are likely to experience some major changes in order to keep pace with the challenges they will face.

> Many small, informally-managed 'lifestyle' companies will eventually have to become more corporate and formal. Mid size companies will have to acquire the management and marketing skills of large companies. (Softletter 100, 1990, p. 1).

The trend to larger company size in the pure software industry of the late 1980s however, was not one of consolidation, but one of small companies becoming big companies (Softletter 100, 1990, p. 1).

IV. BARRIERS TO ENTRY

A. Overview

This discussion of barriers to entry in the computer manufacturing industry, first looks at computer hardware. Using Gerald Brock's most recent analysis as a basis (McAdams, 1990, pp. 163-166), the study provides an overview of historical barriers to entry in the industry in the 1960s and 1970s, focusing on general-purpose computers. To follow the developments affecting barriers to entry in the 1980s, the study will view the factors affecting the mainframe and minicomputer market segments, then focus on the evolution of barriers to entry in the microcomputer segment. The analysis will compare the trends of barriers to entry in the computer manufacturing industry to those of the automobile industry, to illustrate how the computer manufacturing industry followed the automobile industry in creating relatively substantial barriers to entry in manufacturing complete computer systems in the 1980s and early 1990s. Similarly, this study will view the barriers to entry in software development comparing them to those of computer manufacturing.

B. Computer Manufacturing Barriers to Entry, 1960s and 1970s

"By definition, a barrier to entry to a market is a factor which permits a firm (or firms) in the market to raise the

price above a competitive level (above "economic cost") without attracting new entry." (McAdams, 1982, p. 256) With such barriers, firms in the market can earn and maintain economic profits without the threat of competition from new entrants. The general-purpose computer manufacturing market of the 1960s and early 1970s consisted of a relatively few manufacturers (seven to eight), with IBM controlling the market. The major reason for the small number of players was the barriers to entry that existed during the 1960s. McAdams identified the following barriers to entry:

- Software lock-in (designing software to run only on the computer systems hardware of one manufacturer, unless hardware modifications are made)
- Leasing(due to the financial costs to an entrant)
- Bundling (offering a group of products at a single price without individually specified prices for elements that make up the group)
- Regional scale economies
- Customer product loyalty (due to brand name recognition and customer costs of switching)
- IBM conduct (due to the dominance IBM had in the computer industry during the 1960s). (McAdams, 1982, p. 256)

Of these barriers, software lock-in was labeled as being "one of the most pronounced forms of product differentiation recognizable in any market at any time." (McAdams, 1982, p. 257) The strongest barrier in the general-purpose computer market, however, was the conduct of IBM during the period. According to McAdams, "when the more passive, more structural barriers to entry have appeared to be inadequate alone to

foreclose entry into the market, IBM has devised business strategies which when implemented and enforced through its market power, have enhanced preexisting barriers or otherwise have achieved the goal of maintaining IBM's market dominance." (McAdams, 1982, p. 262) The impacts of these barriers to entry, illustrated in numerous cases in the 1960s, resulted in an industry with no new entrants in the 1960s, and only IBM controlling enough of the market to influence the industry.

As the industry progressed through the 1970s, IBM's dominance of the 1960s declined by roughly 30 percent in market share, due to the elimination of the barriers to entry that existed in the 1960s. Though IBM still remained the industry leader, the influence of their conduct as a barrier to entry lessened as plug compatibles and non-IBM minicomputers provided more alternatives to customers.

Legal developments during the late 1960s also helped to eliminate two of the barriers to entry the industry faced in the 1960s. The Department of Justice's decision in 1969, requiring IBM to invoice its hardware and software separately was key in eliminating bundling as a barrier to entry (ICCP, 1985, pp. 55-56).

Additionally, software lock-in was outlawed and eliminated as a barrier to entry as the federal government mandated industry standardization. In 1965, Public Law 89-306 (the Brooks Bill), "assigned responsibility to the National Bureau of Standards to develop computer standards for use within the

government and to coordinate government efforts for joint standardization programs with industry." (Brock, 1975, p. 149) After suggestions for voluntary standardization actions failed, President Johnson, under the authority of Public Law 89-306, issued a 1968 memorandum establishing ASCII as a federal standard (Brock, 1975, p. 150). According to Congressman Brooks, "the adoption of this standard is a most important beginning to a broad frontal attack on the entire standardization problem affecting computer usage." (Datamation Staff, April 1968, pp. 153, 155) As a result, all computers purchased by the federal government, the largest computer user, after July 1, 1969 were required to have the capability to use ASCII. Though this move towards standardization was opposed by the top firms in the computer industry, eventually such standards were implemented. (Brock, 1975, pp. 150-155)

These decreased entry barriers prompted a growth in the number of firms in the computer manufacturing industry during the 1970s and a wider distribution of market share.

C. Computer Manufacturing Barriers to Entry, 1980s and 1990s

The computer manufacturing industry saw major changes in the 1980s and early 1990s, with the PC revolution having the greatest impact on computer manufacturing. Looking at the market segments of mainframes, minicomputers and microcomputers, this study analyzes how the rapid

technological changes of the 1980s affected barriers to entry in each market segment.

1. Mainframe and Minicomputer Market Segments

To better describe the barriers to entry of the computer manufacturing industry in the 1980s, it is useful to identify barriers to entry in the more established automobile industry, and compare the trends in each industry. The three major barrier to entry in the automobile industry are:

- The initial costs to construct an automobile assembly plant and facilities for the production of major components and parts
- The costs and expertise of advertising and selling automobiles
- The assembly of a dealer system for distribution and service, given the competition of the extensive dealer systems of the big three automobile firms. (McAdams, 1990, p. 110)

Comparing these barriers to entry to those of the computer manufacturing industry, the same trends appear in developing, selling, and servicing complete mainframe and minicomputer systems. In the mainframe and minicomputer segments, like the automobile industry, capital availability has been a substantial barrier to entry, due mainly to the firm size, established customer ties, and dealer networks of existing mainframe and minicomputer firms. This is especially true in developing complete computer systems.

In Brock's most recent analysis of the computer industry, he identified the absence of widely accepted

standards as a primary reason for the substantial barrier to entry in developing complete computer systems. He noted that "barriers to entry for complete systems in established markets are extremely high because of the need to assemble a complete system, write a large library of software, and convince customers to pay the high costs of switching from their current supplier to the new entrant." (McAdams, 1990, p. 165) Additionally, customers who switched suppliers often incurred the costs of possibly modifying existing programs and retraining or replacing personnel. Since there were no widely accepted standards, customers also ran the risk of the new system being incompatible with their existing systems (McAdams, 1990, p. 165).

As with the automobile industry, the costs to establish complete mainframe and minicomputer systems internally, in an industry where such systems can be developed from existing components, too often results in unreasonable, uncompetitive prices.

2. Microcomputer Market Segment

Barriers to entry into new market segments of the computer manufacturing industry, such as the microcomputer market segment of the early 1980s, have been relatively low. "The sustained rapid technological progress has continually opened up new areas for the use of computers, and consequently, new opportunities for entry without direct

competition against established companies." (McAdams, 1990, p. 164) Capital availability was not a substantial barrier to entry in the microcomputer market in the early 1980s. Instead, it was a positive incentive for new entry, due to the stock market enthusiasm for new computer companies. According to a Datamation study in 1982, half of all venture capital placed in the early 1980s went into new computer related companies, with the bulk going to the microcomputer market segment (Verity, September 1982, p. 180). The hundreds of upstart microcomputer companies in the early 1980s exemplify the low barriers to entry in the microcomputer market segment (McClellan, 1984, pp. 211-212).

As the microcomputer segment evolved through the 1980s, however, capital availability became a relatively substantial barrier to entry. To be competitive, a new entrant had to pay both the costs of development and the costs of establishing an extensive sales and service network that was competitive with the networks of established firms. Because franchises, such as Computerland, shelved at best five different name brands, new entrants also found it difficult to use established sales networks (McClellan, 1984, p. 212). Another factor contributing to the capital availability barrier is the continual downsizing and budget cutting of the military. In the past, new entrants could rely on large government contracts to alleviate financial burdens (McAdams, 1990, pp. 164-165). With today's military cutbacks, however,

available funds are being channeled more to military personnel and their quality of life, while major programs and their associated funds are cut.

3. Individual Systems Components

Unlike the substantial barriers to entry for complete computer systems, barriers to entry for the components that make up computer systems have been relatively low. "An innovation in one particular component may lead to a viable entry product either by selling the improved component to an established system manufacturer for resale under that brand name or by direct marketing to end users." (McAdams, 1990, p. 165) The computer chip and peripheral markets are examples of two such areas where barriers to entry are low.

The fear of leading computer systems manufacturers in such a situation is that a competitor can combine these individual systems components to market a complete system that will undercut the price of systems manufacturers' products. As a result, "many of the competitive strategies in computer systems have been related to preventing easy entry into piece parts and thereby preserving the freedom for the systems manufacturer to price the various components of a system in order to extract the maximum profit." (McAdams, 1990, p. 165) The push, by leading United States computer systems manufacturers, for legislation to limit the import of less

expensive computer chips from abroad is an example of such strategies.

D. Software Development Barriers to Entry, 1970s

In contrast to the relatively substantial barriers to entry in the computer manufacturing industry in the 1970s, those of the software development industry were relatively low. Until 1969, there was no distinct software development industry. In 1969, the Department of Justice, in a monumental decision for the software industry, required IBM to invoice its hardware and software separately. This "arrangement by which hardware manufacturers supplied software separately, through unbundling, is today regarded as having founded the software market and thereby the software industry." (ICCP, 1985, p. 56)

Legislation in the late 1960s, mandating computer industry standards, also eliminated software lock-in as a barrier to entry. The elimination of software lock-in allowed new entrants to compete against existing firms because customers no longer had to make modifications to their computer hardware in order for new entrants' programs to be compatible.

Although there were not formidable barriers to entry during this period, existing hardware manufacturers took a large share of the market, due mainly to their strength in developing systems software. Customer loyalty and brand name recognition also contributed to barriers to entry, despite the

elimination of software lock-in and bundling. It took new companies time to develop software that would replace the confidence hardware manufacturers built in customers before standardization and unbundling. Applications software during the 1970s was also fairly limited, again allowing existing hardware manufacturers to use their close ties with current customers and strong sales systems to control the software development industry. (ICCP, 1985, pp. 55-56)

E. Software Development Barriers to Entry, The Early 1980s

The 1980s opened with an "increasing public fascination with high technology." (McAdams, 1990, p. 166) As a result, half of all venture capital placed in the early 1980s went into new computer related companies, with investments in software companies becoming a major part of that venture capital (Datamation, September 1982, p. 180). The major reasons for this influx and success of new software development companies in the early 1980s were tied to the rapidly advancing technology of the decade and strategies new entrants devised during the changing times.

1. Rapid Technological Progress

Brock identified the software development industry as having the highest economies of scale of any segment in the computer industry. "Though high economies of scale imply high barriers to entry in many industries, rapid technological

progress prevents the economies of scale in software from forming a barrier to entry." (McAdams, 1990, p. 166)

The PC revolution of the early 1980s helped open the software development industry to new entrants. The extension of computing power to the office, classroom, and home brought with it the potential to automate virtually any task with applications software. While computer manufacturers continued to focus mainly on systems software, new entrants focused on manufacturing applications software. Increased memory capacity, combined with the increasing processing power of microcomputers, from 8088s to the current 80486s, provided platforms with more capabilities. Software developers took advantage of this added computing power, producing software that could do more while being easier for the customer to use. The use of microcomputers as a development platform for software products also helped reduce the initial costs to enter the industry (Rosenthal, June 15, 1985, p. 95). Further, technology was also applied to the actual development of software in the form of software tools that made development more efficient.

This rapid technological progress in software development helped to alleviate the barrier to entry of capital availability in the early 1980s. "For many applications, a small team of programmers or even a single individual could produce a marketable product." (McAdams, 1990, p. 166)

2. Niche Strategies

Even more so than in the manufacturing of computer hardware, software developers used niche strategies to enter into new market segments of the industry. Because there is little competition from existing developers in such market niches, most new entrants develop strategies geared to a particular application (McAdams, 1990, p. 164). Lotus' focus on spreadsheet programs in the early 1980s is a good example of a successful niche strategy.

F. Software Development Barriers to Entry, Late 1980s, 1990s

As the software development industry grew in the 1980s, the industry began to see the same trends in barriers to entry as the microcomputer market. Again following the barriers to entry of the computer manufacturing and automobile industries, capital availability became a substantial barrier to entry for new entrants in software development in the late 1980s and early 1990s. The strong computer hardware manufacturers controlled the bulk of the software development market with IBM, Fujitsu, and NEC controlling over 40% of the market share percentage in 1990. Using their extensive, well-established dealer networks and sheer company size, as well as their close ties to customers who purchased their hardware, these top three companies in software development in 1990 contributed to the capital availability barrier to entry facing the software development industry.

In addition to the strong hardware companies, the shakeout of the software development industry in the late 1980s and early 1990s resulted in a few very strong pure software companies. The top four in order of rank in Datamation's Big 50 Software Companies were Microsoft, Computer Associates, Oracle, and Lotus (Poppel, October 1991, p. 58-62). Like the top companies in computer manufacturing, these strong software companies have established large networks to develop, advertise, sell and upgrade their products. Not only do new entrants have to compete with the applications programs of the software development industry's giants, they must also, in most cases, rely on the operating systems that were developed by large companies, like Microsoft's MS-DOS.

Phil Kahn, CEO of Borland International, a software development company in Scotts Valley, California, accuses Microsoft CEO Bill Gates of ruthlessness in today's software development industry. He cites that "Microsoft's abrupt changes in its operating system strategy, can devastate small software companies (or software startups), whose programs can't sell unless they mesh with Microsoft's." (Schlender, 26 August 1991, p. 43) He further complains of Bill Gates, noting, "when you deal with Gates, you feel raped." (Schlender, 26 August 1991, p. 43)

Mitch Kapor, founder of Lotus Development agrees: "the (software development) business is all about power and market share now." (Schlender, 26 August 1991, p. 43) This hostile

environment, combined with the industry giants' large volume of software sales has further established capital availability as a barrier to entry in the software development industry. Though new entrants can still pursue new market segments, as they did in the early 1980s, they must now overcome substantial initial costs to compete in the industry, especially with the state of the economy and computer industry today.

V. THE PC REVOLUTION

A. Overview

More than any other factor, the rise of the microcomputer, known as the PC Revolution, has changed the nature of the computer industry. In just over 15 years, microcomputers have evolved from crude garage hobbies to sleek, powerful systems that dominate the computer hardware markets of today. This study will review the forces in the computer industry that prompted the development of the microcomputer in the 1970s and show how the forces of the PC Revolution shaped the computer manufacturing and software development industries during the 1980s. The study will then view the impacts the PC Revolution had on computer manufacturing and software development and look at the trends in the computer industry as the revolution matures.

B. Forces Prompting the PC Revolution

To identify the forces behind the development of the microcomputer, this study will look at the state of the industry in the 1970s, focusing on the increasing dissatisfaction with the inflexible traditional mainframe systems and the technological advances of the decade. The study will also view perhaps the most powerful force prompting the PC Revolution, the Hacker Ethic.

1. Increased Competition in the Computer Industry

The dominance IBM enjoyed in the computer industry of the 1960s was challenged in the late 1960s and early 1970s by the introduction of plug compatibles. Competitors claimed that users of IBM systems, the industry standard of the time, could use these higher performing, cheaper replacements without changing programming or customer applications. (Brock, 1975, p. 19-20)

Initially, IBM was slow to react to the plug compatible strategies of competitors, resulting in the entry of many companies, covering a broad line of systems components (McAdams, 1990, p. 172).

> This plug-compatible competition brought about a major change in IBM's strategy and in the overall competitive strategy in the industry. Greater pressure forced faster product cycles and brought prices closer to costs. (McAdams, 1990, p. 173)

The rise of the minicomputer and move towards more distributed computing also increased competition in the computer industry in the 1970s. Focusing on applications in industrial process control and other tasks largely distinct from jobs ordinarily performed by large-scale computing systems, minicomputers offered a low cost alternative to the traditional mainframe systems. The rise of the minicomputer resulted in a highly competitive market segment with a large number of companies, many new entrants, and a market segment without the domineering influence of IBM. (Brock, 1975, p. 20)

2. User Dissatisfaction With Mainframe Systems

In conjunction with the increased competition in the computer industry of the 1970s, increasing user dissatisfaction with the inflexible mainframe systems of the decade also proved to be a powerful force behind the PC Revolution. The numerous, impossible commands and technical aspects of mainframe systems required a knowledge of complicated, structured computer programming languages and experience in the operation of the systems, limiting computing power to a select few. The long turn-around times for jobs and error-prone punch card systems also frustrated users. Limited access to mainframe systems and their limited power in certain applications also resulted in hostility towards the managers of the mainframe systems. Users demanded more access, computing power and flexibility from computers. These demands, combined with the increased competition in the computer manufacturing industry, spurred the technological advances that formed the technical base of the PC Revolution.

3. Technological Impulses

"Improvements in electronic components dominated the technological changes, reshaping the market in the 1970s, especially extraordinary declines in the price and the vastly improved performance of semiconductors." (Flamm, 1988, p. 236) These advances resulted in a move towards the lower end segment of computers. Several companies began packaging kits

of components that hobbyists could put together to build a primitive home computer (McAdams, 1990, p. 174). The central element in this evolution of the microcomputer industry was the microprocessor. Intel's introduction of the Intel 8008 microprocessor in 1972 performed central processing functions and led to rapid advances in computing power (U.S. Department of Commerce, August 1986, p. 11). The following events outline the major milestones in the history of the microcomputer industry:

- 1973 - Scelib Computer Consulting Company introduced the first computer kit to use the Intel 8008 microprocessor
- 1975 - MITS, Inc. developed the Altair 8800, the first commercial microcomputer
- 1976 - Gary Kildall developed CP/M (Control Program Microcomputers), a non-proprietary operating system which became the defacto standard for 8-bit personal computers
- 1977 - Apple introduced the first commercially successful personal computers (Apple IIs) opening the personal computer market from primarily hobbyist to business and home segments
- 1978 - Intel Corporation introduced the 8086 microprocessor, which became the 16-bit industry standard
- 1979 - VisiCalc, the first spreadsheet for personal computers, was marketed by Personal Software, offering businesses the ability to perform limited applications (U.S. Department of Commerce, August 1986, pp. 11-12)

4. Emergence of the Hacker Ethic

While the rapid advances in technology were essential in providing the technical means for the PC Revolution, the commitment of the new breed of computer professionals, outlined in the Hacker Ethic, was the underlying impetus of

the PC Revolution. This mind set evolved from the reclusive computer programmers and designers of the 1950s and 1960s who initially got their infatuation with technology in their model railroad hobby. This select group, shunned by normal people, used their brilliance to overcome the inadequate, crude systems of the time, constantly aspiring to reach their idealistic vision of using the computer to better mankind. Their obsession with computers and using information to better mankind is best described in their Hacker Ethic:

- Access to computers - and anything which might teach you something about the way the world works - should be unlimited and total. Always yield to the Hand-On Imperative!

- All information should be free.

- Mistrust Authority - Promote Decentralization.

- Hackers should be judged by their hacking, not bogus criteria such as degrees, age, race, or position.

- You can create art and beauty on a computer.

- Computers can change your life for the better. (Levy, 1984, pp. 40-45)

The concepts of this Hacker Ethic in action, especially in the late 1970s, began to change the nature of the computer industry. Those who lived the Hacker Ethic established users groups and clubs to practice their beliefs, like the Homebrew Computer Club of the Silicon Valley. Started by hardware hackers, this computer club offered technical advice and a forum for computer hobbyists. Steven Wozniak's development of the Apple computer probably best exemplifies the spirit and

synergy of the hardware hackers. Teaming up with Steven Jobs, the two initially sold Jobs' Volkswagen bus and Wozniak's programmable calculator for capital, and developed the Apple computer, selling it for $666.66. In developing this computer, the two pioneers were not motivated by visions of riches and fame, but by the pleasure the computer could offer to them and their friends. (Levy, 1984, p. 253)

The Hacker Ethic was also in action in the software world of the late 1970s. Motivated by the obsession that all information should be freely exchanged, true hackers offered software either free or at minimal cost, like the free software with Wozniak's Apple computer (Levy, 1984, p. 253). Computer groups and forums would routinely exchange and share programs, giving everyone the opportunity to improve on the program to promote the betterment of the entire group. A few programmers of the late 1970s, however, began to sell their programming efforts on a basis that earned them royalties for every copy sold. Confronted with this contradiction to the Hacker Ethic, true hackers merely pirated the software, "blithely churning out copies and giving them away." (Levy, 1984, p. 229)

This software piracy led to a conflict between the established hackers of MIT, who wrote software and purposely left it at the terminal for others to work on and improve, and a new breed of programmers who viewed their programming as a vital service that should be paid for. Leading the new breed

of programmers was Bill Gates (the soon to be czar of Microsoft) in his public protest against hackers' theft of his Altair BASIC program. Gates' accusation, later known as the "software flap," created a major conflict in the hacker community between the traditional hardware hackers and this new breed of programming hackers who had the gaul to attempt to sell information. While Gates' complaint did not stop software piracy, the separation in the hacker community helped spark the emergence of a previously underdeveloped segment of the computer industry, software development. (Levy, 1984, pp. 229-231)

C. Forces of the PC Revolution

The forces of increased competition in the computer industry, rapid technological advances, and the Hacker Ethic, set the stage for the PC Revolution of the early 1980s. These forces of the late 1970s, and other forces of the PC Revolution, fueled the emergence of the microcomputer market and changed the structure of the computer manufacturing and software development industries. This study will view these forces of change and look at how the strategies of the major players in the computer industry adapted to these forces.

1. The Emergence of the PC Market

Apple Computer's introduction of its line of inexpensive machines, equipped with software and peripherals, transformed the microcomputer market from an experimental

niche to a major market (McAdams, 1990, p. 174). Fueling this transformation of the microcomputer was the rapid advance of communications technology in the late 1970s and early 1980s. As new high speed communication links emerged, including digital switches and optical fiber, users could transmit data faster and cheaper. These communication advances made it more economical, in a number of cases, to link less expensive microcomputers to perform certain computing functions, rather than rely on large, centralized computers. Communication links also allowed users to link their microcomputers to the power of mainframes for special purpose computing. (Flamm, 1988, pp. 238-239)

Comparing the mainframe, minicomputer and microcomputer market segments of the computer industry illustrates the growth of the microcomputer through the PC Revolution. Figure 11 depicts these market segments in constant 1990 dollars in the 1980s, and shows the rapid growth of microcomputers from a mere 1.2 billion in 1980 to 39 billion in 1990. A major reason for such rapid growth was the microcomputer's ability to penetrate virtually every existing market segment. This study uses the U.S. Department of Commerce's definition of microcomputer application segments.

- The Business/Professional Market - representing the commercial applications of microcomputers
- The Home Market - representing the use of microcomputers in the home for non-business applications

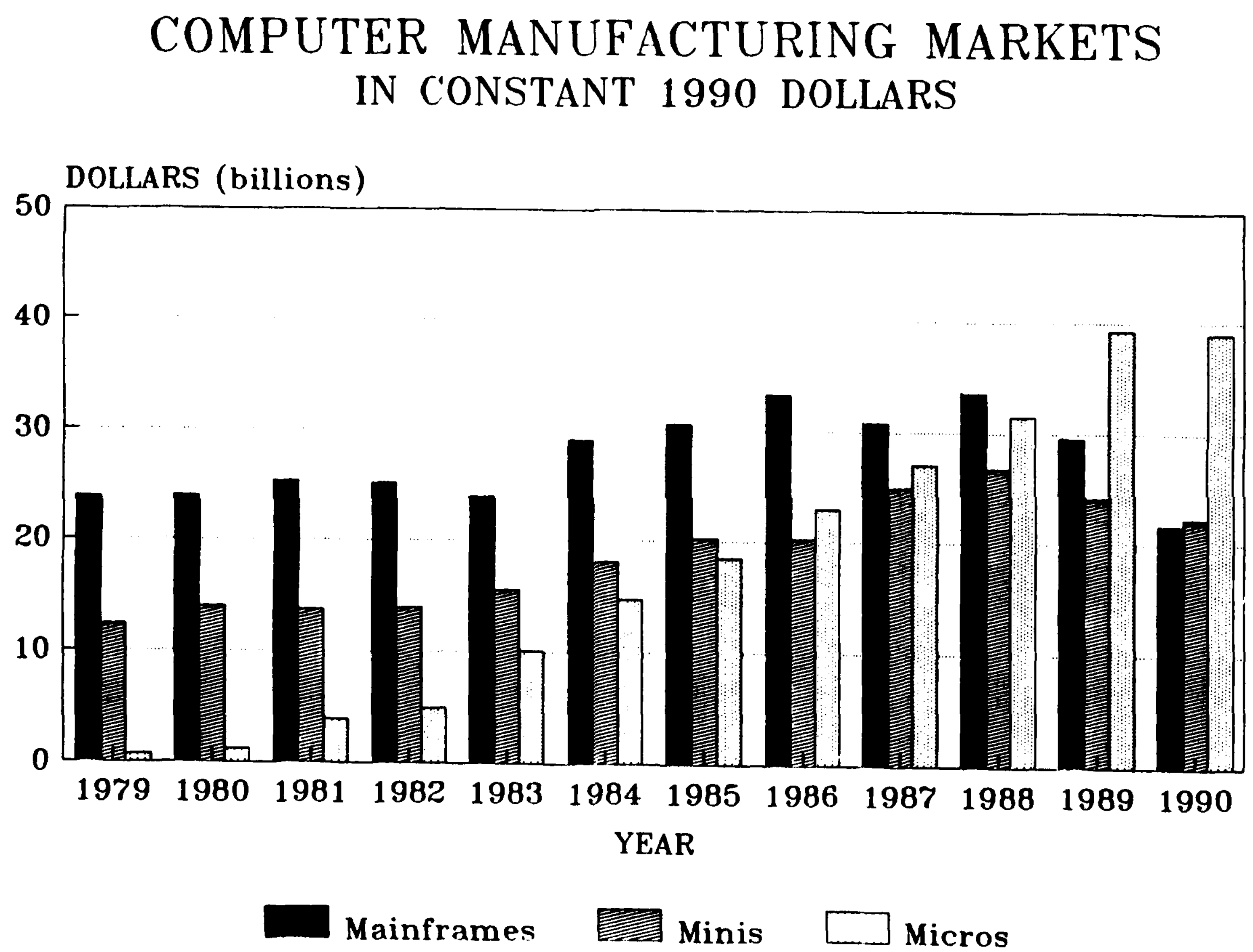

FIGURE 11 (Source: TABLE 23)

- The Scientific Market - consisting of microcomputers used in a laboratory environment for non-business applications
- The Education Market - including all microcomputers sold to educational institutions for classroom use (U.S. Department of Commerce, August 1986, pp. 4-5)

By targeting any or all of these potential markets, the major firms in the computer industry, as well as many new entrants, quickly expanded the growth of microcomputers.

2. The Changing PC Market

The market potential of the microcomputer in the early 1980s combined with the flood of venture capital into computer-related companies, resulted in a rapidly developing segment. Known as the Personal Computer Phenomenon, the microcomputer industry attracted competition from as many as 150 companies in the early 1980s (McClellan, 1984, p. 211). While IBM's influence was absent from the initial growth of the microcomputer market segment, they answered the call in 1981 with their introduction of the IBM PC (McAdams, 1990, p. 174). IBM's PC quickly became the industry standard, controlling over 14% of the microcomputer market share in 1982 and 33% in 1983 (Archbold, June 15, 1983, pp. 86-91, Archbold, June 15, 1984, pp. 52-57). While IBM offered several technical advantages over the previous leader, Apple, "the IBM name and support helped many corporations to purchase large numbers of the machines with the expectation that they could be more easily integrated into corporate data processing

procedures than could Apple." (McAdams, 1990, p. 174) IBM legitimized the PC in the computer industry. Big Blue's entry into the PC market probably marked the end of the revolution.

The market share percentages of the top three microcomputer manufacturers (Figure 5-2) illustrates the changing microcomputer market through the PC Revolution. As IBM continued to grow in microcomputer market share in the early 1980s, capturing the business/professional market from Apple, the microcomputer industry saw a major shakeout of companies (McClellan, 1984, pp. 211-212). In order to survive the shakeout, companies had to target segments of the microcomputer market where IBM had less influence. Tandy, a survivor of the shakeout due mainly to its own distribution channels, used such a strategy focusing on the home computer market against IBM's poor showing with the PCJr.

Another successful strategy to combat the shakeout that developed into a thriving market was making computers that were IBM compatible. While IBM's open architecture allowed it to make a fast entrance into the microcomputer market, it also provided opportunities for competitors to develop software and upgrade components for the IBM PC, as well as entire clone systems with their own brand identity (McAdams, 1990, p. 174). Such IBM clone systems increased competition and decreased prices in the microcomputer arena, drastically decreasing IBM's control of the microcomputer market in the mid 1980s. IBM also lost credibility and lustre

as a break-through technology company. The PC revolution revealed IBM to be marketing-oriented/driven, not technology driven. It offered second rate technology and made several mistakes in the PC market, such as the PCJr. and deliberate crippling of the 286. For the first time, computer users learned they got better technology at a lower price from other sellers. As shown in Figure 12, IBM's microcomputer market share percentage dropped from 36% in 1985 to 16% in 1986, while Compaq's, the most successful of the clone makers, increased its microcomputer market share from 1% in 1983 to 9% in 1990. To combat this clone strategy, IBM introduced a new line of personal computers in 1987, the Personal System/2 (PS/2) with increased technological improvements and a more proprietary architecture. This IBM move did not change the strategy of the clone makers who continued to produce cheaper clones of old IBM models. This strategy proved successful due to a general customer acceptance of IBM-compatible, non-IBM products and to the strong hold that MS-DOS, the operating system of the older IBM PC models, had on the operating systems of the microcomputer market. (McAdams, 1990, p. 175)

Apple, who developed its own operating system, led the microcomputer industry in the early 1980s, but fell to second in market share percentage as IBM entered the micro market. Apple, however, continued to maintain a consistent market share through the revolution due mainly to the ease of use of

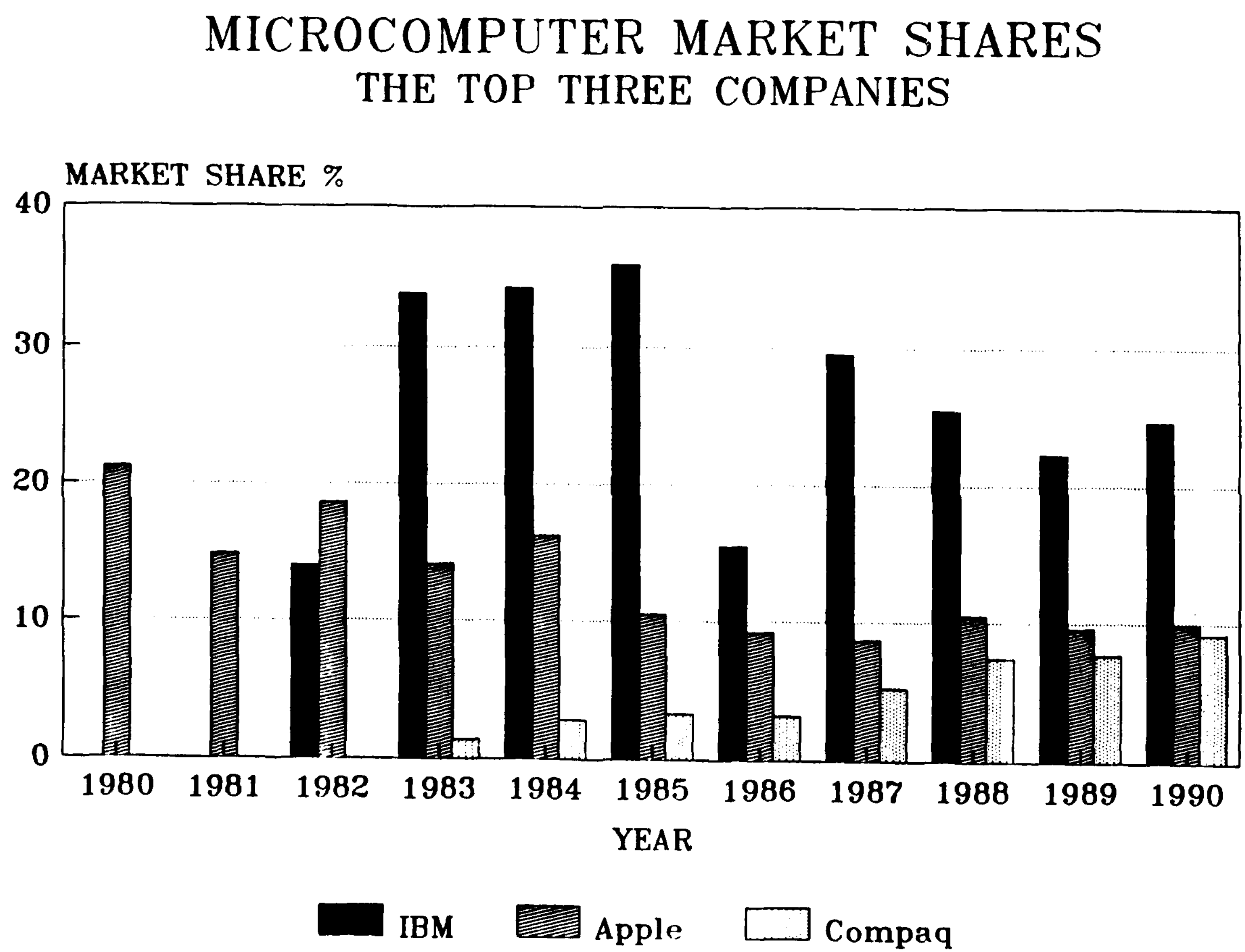

FIGURE 12 (Source: TABLES 46-56)

its operating system. Touted as being the computer for people who do not want to know about computers, Apple's window approach to user interfaces provided users with the capability to tap computing power without having an extensive knowledge of operating system commands.

The end result of the clone industry and the increased entry of foreign firms into the microcomputer market was a large, highly competitive microcomputer industry, devoid of the IBM dominance of past decades (McAdams, 1990, pp. 174-175). The real winner in this market, in keeping with the Hacker Ethic, is the user, who constantly gains easier, cheaper access to more and more information.

3. Growth of the Software Development Industry

The PC Revolution of the 1980s opened a whole new market for the software development industry. While software development in the 1970s was focused on systems software and limited applications software for the large, centralized systems of the decade, software development in the 1980s shifted to the microsoftware market. The introduction of microcomputers offered software developers the opportunity to develop systems software for the new microcomputer systems, such as Microsoft's development of MS-DOS. More importantly, the potential use of the microcomputer in virtually every business, home, and school provided a wide range for the development of applications software.

A comparison of the two segments after the influx of microcomputers illustrates the force the microcomputer had on software development in the mid and late 1980s. Table 78 depicts the microcomputer and software development market segments in constant 1990 dollars from 1984 to 1990. Figure 13 is the graphical portrayal of those figures showing how software development's growth mirrored the growth of the microcomputer market segment in the mid and late 1980s.

D. Impacts of the PC Revolution

The forces of the PC Revolution have changed the structure of the computer industry, from the competition and strategies of hardware and software manufacturers to the nature of computing. Looking at the impacts of the revolution in the hardware and software market segments through the 1980s and early 1990s, one can identify the major trends that have evolved as the PC revolution matures.

1. Computer Confusion

While high competition in the microcomputer market segment in the late 1980s and early 1990s continues to decrease the price of computers and increase their computing power, the myriad of hardware choices, operating systems, and user interfaces available today has created an environment where clear choices are impossible. While some critics claim that companies behind in technology are intentionally creating

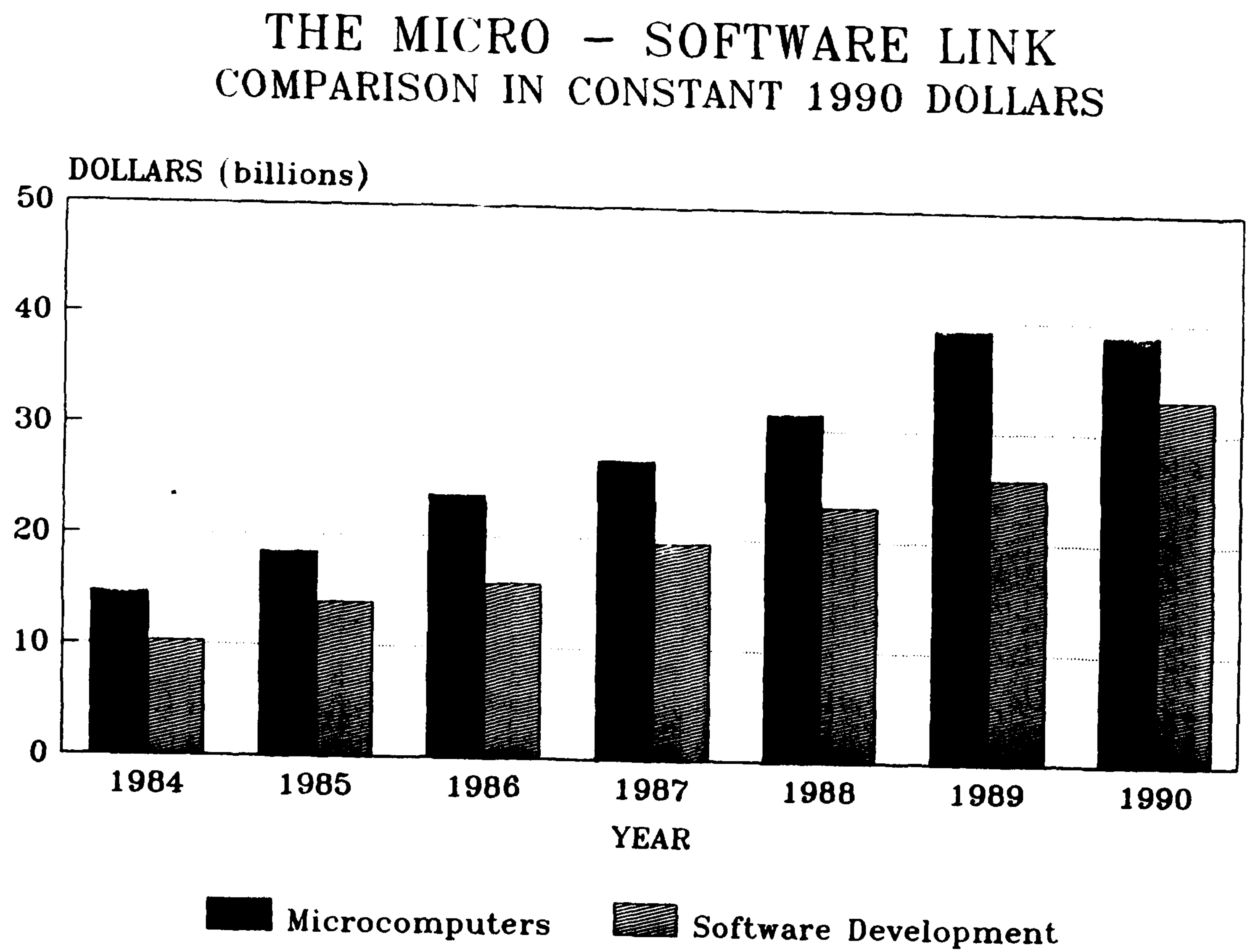

FIGURE 13 (Source: TABLE 78)

the confusion as a marketing technique to buy time for them to catch up, most industry players recognize that the problem is more deeply rooted. (Verity, June 10, 1991, pp. 72-75)

The crux of the computer confusion boils down to standards for hardware, software, and communications interfaces. The solution to this confusion, according to computer executives, is open systems. Computer makers will probably never totally agree on a market-wide definition for an open system, due to each company's potential to gain or lose depending on how an open system is defined (Verity, June 10, 1991, p. 74). In general, an open system, "refers to the use of stable, publicly defined, or "standard interfaces between computer systems or between components inside those systems" (Hof, June 10, 1991, p. 74). The major problem creating the computer confusion of today is the result of each computer maker's scramble to make his product the accepted standard (Verity, June 10, 1991, pp. 72-75).

Computer makers, in purely political moves, are trying to bend the standards movement to their advantage. These political moves include the formation of groups, such as the Open Software Foundation (OSF), continuous deals, alliances, and endorsements, as computer makers attempt to make sure that they can live with the standards that prevail. (Verity, June 10, 1991, pp. 72-75) In this confusing, highly competitive market, like the clone market of the late 1980s, the user is again the real winner, as computer companies constantly

increase their products' computing abilities while decreasing their prices. The user's problem today, however, is obtaining enough education to wade through the computer confusion before buying.

2. The Changing Way of Computing

The PC Revolution of the 1980s "marked the passage from an era of large, centralized computer installations to a world in which vast numbers of more inexpensive machines, distributed widely among users, are tied to one another and to a shrinking number of specialized, centralized computing resources." (Flamm, 1988, p. 239) The constantly increasing power per dollar of today's machines, (such as 486s, Macintosh's QuadroPro, and workstations), has further eroded mainframe usage in the 1990s, as networks of these super microcomputers replace many mainframe functions.

Another change the PC Revolution contributed to the changing nature of computing is end user computing, a step beyond the distributed computing concepts prior to the revolution. As the microcomputer systems of the late 1980s and early 1990s increased in power, they provided the capability to make the details needed to develop applications more transparent to the user, resulting in user interfaces that are easier to grasp by non-computer professionals. Using these improved interfaces, such as menus and icons, end users can quickly grasp the concepts they need to manipulate

programs. This ability allows users to develop applications in hours, that would have taken months to develop a decade ago. The end user benefits by getting his application quicker and by having the ability to make his own modifications to the application. Software programmers also benefit by letting end users help to decrease the already overwhelming software backlog programmers face, allowing programmers to concentrate on the more complex software problems of today.

3. Impact on Software Development

The PC Revolution, more than any other force, was responsible for the phenomenal growth of the software development industry in the late 1980s. The penetration of the microcomputer into businesses, homes and schools, combined with the constantly increasing power microcomputers offer, widened the software applications market considerably and sparked the emergence of pure software companies in the 1980s.

The PC Revolution has also affected the actual development of software. More software development firms are redirecting program development from expensive mainframes to cheaper, easier to use microcomputers that are networked to higher-powered servers. Dun and Bradstreet (D&B) Software is using the software tools of Powersoft Corporation in conjunction with super microcomputer networks to develop one of the hottest upcoming trends in the industry, known as "client-server" applications software. By placing more of the

burden on the powerful, easier to use microcomputers, client-server computing can improve programming operations and save money. (Bulkeley, July 30, 1991, p. B1) Another major trend in software development, geared towards end-user computing, is off-the-shelf software packages, which provide frameworks for building applications using the ease and power of microcomputers.

The trends in the software world, more than any other segment of the computer industry, exemplify the concepts of the Hacker Ethic. As the PC Revolution brought computing power to the masses, followers of the Hacker Ethic educated the masses, freely distributing information through shareware and freeware. Moves in the software world towards easier interfaces and the promise of future compatibility among operating systems is also in line with the Hacker Ethic's concept of total access to information for the betterment of people.

4. Maturation of the Revolution

Throughout the PC Revolution, computing and communications technologies, which were viewed as separate and discrete prior to the 1980s, have rapidly approached a point of mutual dependence. The systems of today signify the end of the revolution and exemplify the continuing convergence of computing and communications into one entity, information processing (Weil, 1982, pp. 204-205). The information systems

of today, such as Local Area Networks (LANs) and diskless workstations, rely not only on the computing power of the machines, but also on PC-mainframe links and communications protocols. Communications technology has become essential to meeting the demands users place on the information systems of today.

In the computer manufacturing industry, miniaturization continued to be one of the hottest trends as the revolution matured. The industry of the 1980s saw the computing power of a 1970s mainframe condense to a desktop machine. The industry will continue to see computers shrink from the current latops and notebooks of today to pocket size machines, as technological innovations overcome the current screen and input inadequacies.

The computer industry is also seeing a maturation of people, as managers change their focus from the hardware issues of the 1980s to concentrate on the value of information. The PC managers of today exemplify this change of focus, as they concern themselves with vertical integration of systems, data administration, and data integrity issues, rather than the data processing issues of the 1980s.

VI. LEGAL ASPECTS OF THE COMPUTER INDUSTRY

A. Overview

The legal issues in the computer industry are generally targeted at striking a balance between innovation and incentives within the industry. While innovation plays a significant role in many industries, it is the critical role in the computer industry. "The ability of businesses to remain or become commercially viable within computer and information industries often hinges on their ability to lead-or at least closely follow-technological innovation." (Nimmer, 1985, p. I-1) While our legal system attempts to encourage innovation, it must also protect the creator of computer-related products in exercising the right for exclusive personal use of his product, or in obtaining compensation for its dissemination (Nimmer, 1985, p. I-1).

The primary areas of law affecting this concept of innovation in the computer industry are copyright, patent, trade secret, and antitrust law. This study will define each area of law, view the major decisions affecting the changing interpretation of each law as it applies to the computer industry, and view the impacts of recent and pending decisions on the structure of the computer manufacturing and software developement industries. Similarly, the study will look at

the government's role in the computer industry and the impacts of government actions on the industry's structure.

B. Copyrights

Historically, copyrights were developed to protect the expressive works of authors and artists. Applied to the computer industry, the use of copyright has evolved as a major form of protection for computer software. The relationship between copyright, which "emphasizes the private, proprietary nature of information," (Nimmer, 1985, p. 1-2) and computer technology, which emphasizes the public nature of information, has created a conflict that affects the structure of the software development and computer manufacturing industries. (Nimmer, 1985. pp. 1-2 - 1-3)

1. Software Development

The problems in the legal protection of computer programs stem from the unique, complex nature of computer software. In general, a computer program is recognized as having two major elements: the written program and the underlying process. While the written program, as a set of instructions expressed in a certain form, falls within the scope of copyright, the underlying process may be regarded as a form of intellectual property, protected by patent laws. The combination of these elements, or either element alone, can further be regarded as protected under trade secret laws,

further complicating the protection of computer software. (ICCP, 1985, p. 159)

Section 102 of the Copyright Act provides the basic criteria to determine whether any work, in general, qualifies for protection under copyright law:

> (1) the work must be an 'original (work) of authorship'; (2) it must be "fixed in (a) tangible medium of expression from which (it) can be perceived, reproduced or otherwise communicated..."; and (3) protection of the subject matter must not extend "copyright protection...to any idea, procedure, process, system, method of operation, concept, principle of discovery...in such work. (Nimmer, 1985, p. 1-3)

In the 1960s and 1970s, software was guarded primarily by trade secret laws, because most software was proprietary to the user and written for pay by employees. The entry of computing power into mass markets and the emergence of the software industry in the late 1970s prompted an amendment to the Copyright Act, to better protect computer programs in this new environment (Nimmer, 1985, pp. 1-9 - 1-10). In 1980, this amendment gave software developers the same protection novelists and songwriters enjoy (Schwartz, May 13, 1991, p. 106). The central premise for this 1980 amendment "was the view that programs constituted the product of great intellectual labor that merited legal protection." (Nimmer, 1985, p. 1-11) In order to encourage the creation and broad distribution of computer programs in the competitive market, Congress recognized that some form of protection against

unauthorized duplication was necessary (Nimmer, 1985, p. 1-11).

In applying these concepts of copyright to the software developement industry, most of the litigation focused on machine outputs. Within this context, two distinct copyrightable works can be associated with a computer program: the object code and the output of the program in audio, screen display, or printed form. The later of these issues has moved to fore-front in the software developement industry. (Nimmer, 1985, P. 1-12 - 1-17)

A noteworthy case concerning the copyrightability of program output in the software world is the case of Whelan Associates vs. Jasow Dental Laboratory. In this case, the court held that a program that performed the same function as a copyrighted program, though written in a different source language for a different computer, infringed on the copyright of the original program. (McAdams, 1990, p. 180)

Encouraged by this decision, other firms have suggested that software copyrights become more expansive. Lotus Development Corporation filed suit against producers of programs similar to their 1-2-3 spreadsheet package, claiming that the other programs had the same "look and feel" of Lotus 1-2-3 (McAdams, 1990, p. 180).

In a similar case, Apple Computer's three year old lawsuit against Microsoft and Hewlett-Packard alleges that "its two rivals illegally copied visual displays that give

Apple's Macintosh computer a unique look and feel." (Yoder, August 16, 1991, B4) Again the heart of the matter, yet to be decided, is whether Apple's copyright extends to the "look and feel" of its software (Schwartz, May 13, 1991, p. 106).

2. Computer Manufacturing

While copyrights in the computer industry are targeted at software, the effects of litigation have the potential to affect hardware manufacturers. A major case in current litigation challenges the concept of clone computers. The case stems from IBM's copyrighted BIOS program, "a program that served as a bridge between the IBM personal computer's hardware and software." (Schwartz, May 13, 1991, p. 104) Clone computers require compatibility with IBM's BIOS program. To make legal clones, programmers mimicked the functions of the IBM software without actually copying it (Schwartz, May 13, 1991, p. 104). Thus, clone makers produced a BIOS program, with different code, that performed the same functions as IBM's program and resulted in the rapid growth of the IBM compatible clone market. "If copyright protection extends to the look and feel of a program rather than merely the actual language in which the program is expressed, then it would be a reasonable implication that a BIOS program that performs exactly the same functions as the IBM BIOS violates IBM's copyright." (McAdams, 1990, p. 180)

Another key hardware issue affected by copyright law in the 1980s focuses on the circuitry of silicon chips. Recognizing the economical and technical significance of microchip designs in the expanding computer market of the 1980s, Congress enacted the Semiconductor Chip Protection Act of 1984, "with the intention of resolving uncertainties in copyright treatment of semiconductor masks and products." (Nimmer, 1985, p. 1-39) The Chip Act, that protects the depiction of planned chip circuitry (the mask) and the chip topology, is recognized as the first new form of intellectual property law in the computer industry, blending copyright, patent, and trade secret concepts (Nimmer, 1985, p. 1-38 - 1-39). This unique blend may be the combination needed to protect manufacturers against exploitation while encouraging innovation (Nimmer, 1985, p. 1-39).

The decisions of pending cases involving the extent of copyright protection will have a major effect on the structure of the computer industry. "If copyright protection is defined expansively, market power will increase for both hardware and software producers as basic concepts become off limits to imitators." (McAdams, 1990, p. 181)

C. Patents

While copyright law in the computer industry is generally geared towards computer software, patent law primarily affects developments in computer manufacturing. Recent moves in the

software industry concerning patent law; however, have the potential to complicate and shakeout the software development industry as well.

1. Computer Manufacturing

While patent law, like copyright law, provides a creator with economic incentives for his work, granting the creator control over his product, there is a major distinction between the focus of the two laws.

> Unlike copyright protection, patent rights are not restricted to preventing appropriation of the invention in the form of direct copying. Rather, the exclusive rights of the patent holder extend to prevent actions on the part of independent developers of the same process or object. (Nimmer, 1985, p. 2-3)

In the expanding computer manufacturing industry, various elements of computer architecture and manufacturing have been subject to patent protection. The primary focus in the computer manufacturing industry is in assessing the degree of change embodied in an invention claim relative to the current status of information technology (Nimmer, 1985, p. 2-35). This focus "is not on the extent of physical change, but rather on the significance and purpose of the change itself." (Nimmer, 1985, p. 2-35)

The most recent patent law case in the computer manufacturing industry centered on alleged violations of patents on memory chips. In September of 1991, Chips & Technologies asked the International Trade Commission to bar the import of computer chips made by four rivals, claiming

that the rivals were infringing on its patents for innovations that improve electronic memories in chip sets (Yoder, September 13, 1991, p. B12).

In a similar case, Wang Laboratories won a suit against two Japanese semiconductor firms that could result in patent royalties of $12 million per year. In this case, Wang sued NEC Corporation and Toshiba Corporation, "alleging that their single-in-line-memory-modules, known in the industry as SIMMs, violated patents it (Wang) was granted in 1987." (The Wall Street Journal, August 16, 1991)

2. Software Development

In contrast to the idea of software patents a decade ago, broader patent rights are extending to the software development industry of today. A recent suit won by Hayes Microcomputer Products Inc. illustrates the impact of patent law in the software development industry.

Hayes, a modem maker, had a patent on a program that switches modems from transmit to receive mode. This patent, unlike a copyright, gave Hayes exclusive rights to any program that performed the same function. Three Silicon Valley modem makers mimicked the functions of Hayes' modem program in the same way clone makers mimicked the functions of IBM's BIOS program. These companies were ordered by a federal court to pay Hayes $10 million in damages for patent infringement. (Schwartz, May 13, 1991, p. 104)

This case, according to legal counsel for top companies in the industry, is just the beginning. Michael H. Morris, general counsel for Sun Microsystems observes, "there are thousands of software patents now winding their way through the system that are about to explode on the scene." (Schwartz, May 13, 1991, p. 104) Big companies are now routinely filing for software patents in addition to copyrights. IBM already has at least twice as many software patents as any other company, and Microsoft began their move in routinely filing for patents two years ago. Small companies fear that pending patent holders will exact high licensing fees from rivals, driving competing products from the market. (Schwartz, May 13, 1991, p. 106)

Among the worst fears in the software community is that patents will be granted for computer interfaces. Such patents would result in a situation similar to the legal battle between Nintendo and Atari involving Nintendo's interface patent for its "lock out device." Small software makers fear that such interface patents in the software development industry could have devastating effects, perhaps making it impossible to link different computer brands without first paying royalties. (Schwartz, May 13, 1991, p. 106)

In an attempt to promote continued innovation for all software firms, Congress, the Commerce Department, and the Office of Technology Assessment (OTA) are reviewing the need for new rules for software patent protection. They are

considering controversial software copyright issues, such as the "look and feel" of computer programs. The OTA is readying a proposal for Congress, due in January 1992, that will lay out options for legislation. By August 1992, a commission of software business executives, under the leadership of Commerce Secretary Mosbacher, plan to propose the first major rewrite of the Patent Act in 40 years. (Schwartz, May 13, 1991, p. 106)

D. Trade Secrets

The third major form of intellectual property law, used little today but interesting from an historical perspective, is trade secret law. Primarily state laws, trade secret laws "protect processes and ideas that cannot be protected by copyright law and that lack the level of inventiveness necessary for patent protection." (Nimmer, 1985, p. 3-2) Unlike copyright and patent laws, trade secret law does not require disclosure, permitting confidentiality of commercial advantages (Nimmer, 1985, p. 3-2).

1. Definition

The Restatement (First) of Torts defines what is characterized as a trade secret:

> (A trade secret consists of) information which is used in one's business and which gives him an opportunity to obtain an advantage over competitors who do not know or use it...A substantial element of secrecy must exist, so that, except by use of improper means, there would be difficulties in acquiring the information...Protection is not based on a policy of rewarding or otherwise

> encouraging the development of secret processes or devices. The protection is merely against breach of faith and reprehensible means of learning another's secret. (Nimmer, 1985, p. 3-3)

Unlike patents, which are generally geared towards computer hardware issues, and copyrights, generally geared towards software protection, subject matter for trade secret protection applies to both computer manufacturing and software developement (Nimmer, 1985, p. 3-2).

In the computer industry, the most frequently litigated trade secret case occurs when an employee who has access to an employer's trade secrets leaves to join another company, or to form his own company. Litigation in the competitive computer industry, where innovation is critical to success, becomes even more frequent as competitors entice selected employees (those who are privy to secrets) to join their firm. (Nimmer, 1985, p. 3-26)

Such a pattern arose in Telex Corporation v. IBM in 1975. In an effort to stay abreast of IBM, the current industry leader, Telex hired employees involved in sensitive IBM projects to obtain inside information about the projects. The court held that luring away key IBM employees violated trade secret law. (Nimmer, 1985, p. 3-39)

Trade secret laws have also had an impact on the increasing practice of reverse engineering in the computer industry. Unlike copyright and patent law, trade secret law provides that "the purchaser is free to disassemble and

inspect the products, most significantly use the information thereby obtained." (Nimmer, 1985, p. 3-19) While the capability to reverse engineer an item is legal, obtaining trade secrets through confidential documents or microcode is protected under trade secret law. In 1973 case, Data General vs. Digital Computer Controls Inc., the court found that Digital Computer misappropriated Data General's trade secret because it used confidential documents, in conjunction with a legally purchased Data General computer, in its reverse engineering process. (Nimmer, 1985, p. 3-21)

To avoid trade secret law problems, firms in computer manufacturing and software development have turned to the concept of "clean room" processes. Such processes attempt to confine the ideas and work of developers to a designated workplace, and prohibit any potential forms of trade secret violations from entering or leaving the area.

E. Antitrust

Beyond the three major laws protecting intellectual property, innovation is also directly affected by antitrust statutes, which establish the boundaries of lawful competition. Antitrust statutes are outlined in the Sherman Act and the Clayton Act. Like intellectual property law, they support the concept that an appropriate legal system should encourage technological innovation, yet they use an approach that diametrically opposes the approach of copyrights,

patents, and trade secrets. The intellectual property laws try to foster innovation by granting a license for a monopoly. Conversely, antitrust laws attempt to preclude a monopoly so that competition will encourage innovation. (Nimmer, 1985, 4-31 - 4-32) These antitrust laws "derive from congressional policy against monopolistic control of commercial markets and distinguish acceptable and unacceptable competitive actions." (Nimmer, 1985, p. 4-32) The history of antitrust law in the computer industry, from the late 1960s to the present, shows how antitrust law helped to shape the structure of the computer manufacturing and software developement industries.

1. Antitrust Law in the Late 1960s and 1970s

In the computer industry of the late 1960s "one firm dominated the industry, barriers to entry were high, and there was evidence of conduct designed to maintain a monopolistic position." (McAdams, 1990, p. 178) IBM's dominance of the industry in the late 1960s, at the peak of the System/360's success, made IBM a natural target of antitrust lawsuits. Control Data filed the first noteworthy suit against IBM, alleging that "IBM's losses on the 360/91 (a system competitive with Control Data's 6600 supercomputer) were evidence of predatory pricing." (McAdams, 1990, p. 177) After several years of legal battle, Control Data received a substantial, undisclosed payment from IBM concerning this suit in an out-of-court settlement (McAdams, 1990, p. 177).

In 1969, the Department of Justice filed a major public antitrust suit against IBM, seeking the dismemberment of the company. The pretrial proceedings and lengthy trial in this suit lasted from 1969 to 1982. It was finally dropped by the Reagan Administration due to increased competition in the computer industry and IBM's modification of the practices initially cited in the suit. (McAdams, 1990, p. 178)

IBM's strategy to combat the plug-compatible peripheral market in the 1970s led to a series of private antitrust suits. Although these peripheral cases were eventually settled out of court, or ended in trial victories for IBM, antitrust helped to "level the playing field" in the computer manufacturing industry, making the industry of the late 1970s substantially more competitive. (McAdams, 1990, p. 178)

2. Antitrust in the 1980s and 1990s.

The computer industry of the 1980s saw a shift in antitrust litigation, from computer manufacturing issues to a broader spectrum of concerns that had become integral to the industry, such as communications and software issues.

The merging of computing and telecommunications technologies prompted a merging of legal issues as well. The computer industry's growing dependence on communications led to two Federal Communications Commission (FCC) computer inquiries in 1970 and 1976. The focus of these inquiries was

to prevent undue leveraging of economic and technical power across the two technologies. (Nimmer, 1985, p. 11-5 - 11-6) These FCC actions prompted the antitrust litigation that led to the breakup of American Telephone and Telecommunications (AT&T). In 1982, AT&T agreed to break up the Bell System in return for a measure of freedom in expanding to unregulated technologies. This break up thrust the nation's telephone system into a period of massive change, characterized by the establishment of local operating companies (Nimmer, 1985, p. 11-6).

Due to the computer industry's increasing reliance on communications, AT&T's divestiture created opportunities for data communications companies in the mid 1980s. From 1983 to 1984, leading data communications companies grew by more than 50% (Verity, June 1, 1985, pp. 36-41). The proliferation of communications options helped to increase competition in the computer industry as well (Nimmer, 1985, p. 11-3 - 11-6).

AT&T's settlement also allowed them to compete in the data processing and information service markets. Though AT&T's debut in the computer industry was not overwhelming, AT&T was recognized as a player that would affect the future of the industry (Archbold, June 1, 1984, pp. 52-57). In retrospect, AT&T's Unix operating system was perhaps its most significant contribution to the computer industry, as moves towards standardization favor Unix as the standard operating system in the industry to come (Verity, June 10, 1991, p. 72).

In the early 1990s, the computer industry saw yet another shift in major antitrust litigation. Attention shifted to the fastest growing segment of the computer industry, software development. In 1990, the Federal Trade Commission (FTC) launched an investigation of Microsoft's alleged domination of the computer software industry. While the investigation was initially focused on the legalities of the operating system battle between IBM and Microsoft, the investigation has become much broader and could involve improper sharing of information between Microsoft's operating system and applications software divisions. According to Bill Gates, Microsoft's CEO, the worst case scenario is that the government would order Microsoft to break into two companies, in a move similar to the break up of AT&T. One of the companies would focus on operating systems, the other on applications. (Rodgers, June 24, 1991, p. 39)

The impacts of such antitrust action in the software development industry could be global in scope. While the United States is currently the world leader in software development, competition from abroad, especially from Japan, is closing the gap. Critics of antitrust actions in the software development industry fear that a proliferation of antitrust lawsuits, such as the one against Microsoft, could burden the industry and jeopardize the United States' current lead in the industry. (Rodgers, June 24, 1991, p. 39)

F. Role of the Government the Computer Industry

Ultimately, government action, whether legislative or judicial, has been the driving force in protecting intellectual property and promoting innovation in the computer industry. This section of the study will view government actions beyond the confines of copyright, patent, trade secret, and antitrust law, tc show how these actions have helped to shape the market structure of the computer industry.

1. Research and Development

Federal support for computer technology has been instrumental in funding research and development of emerging technologies and in providing the largest user in the computer market. Prior to the mid 1950s, all major computer technology projects in the United States were supported by government and military users. (Flamm, 1987, p. 42) While a commercial, business-oriented market for computers grew in the late 1950s and early 1960s, "government users still dominated in high performance, large-scale scientific computers, and advanced technology projects paid for by federal authorities accounted for much of the technical advance in computers." (Flamm, 1987, p. 42)

In the late 1960s and early 1970s, as the commercial market matured, "entry into the hardware competition was largely confined to firms specializing in low-end applications (often based on minicomputers) and high-end, very large-scale

computers (supercomputers)." (Flamm, 1987, p. 43) While the government only played a small role in the low-end of the market, they played a direct, significant role in the high-end supercomputer market. The computer industry of the 1970s also saw a shift in government funds, from support for existing computer technology to more support for research and developement efforts focused on leading-edge concepts. (Flamm, 1987, pp. 43-45)

The Defense Advanced Research Projects Agency (DARPA) became a critical organization in managing these R&D efforts. Initially organized in 1957 to oversee the United States space program, DARPA expanded its role to control 50% of the R&D budget for military sciences in 1965. As military research funding declined in the early 1970s, DARPA's dominance, especially in the computer science, became even more complete. The organization played the key role in setting military computer research priorities. Because DARPA recognized the military's potential benefit from the procurement of commercial computer products, the agency was not exclusively focused on support for military applications, but on supporting the acceleration of technological developments throughout the computer industry. (Flamm, 1987, pp. 52-55)

"Centers of excellence for computer research across the country greatly benefitted from healthy injections of DARPA funds." (Flamm, 1987, p. 55) These centers included MIT, Stanford, the University of Michigan, SRI International,

and Systems Development Corporation (SDC). DARPA's funding of such research efforts sparked computer technology innovations that changed the market structure of the computer industry. Innovations derived from these efforts include timesharing, networks, artificial intelligence, and advanced microelectronics. (Flamm, 1987, pp. 51-55)

In addition to DARPA, other government actions were fostering research and development in the computer industry. The Joint Research and Development Act of 1984 was "perhaps the most important legislation affecting market structure in technology-intensive industry in recent years." (Flamm, 1987, p. 114) This act encouraged firms to undertake cooperative research by limiting damages from potential private antitrust cases against firms involved in approved ventures. Within one year of the Act, fourteen joint ventures had requested approval from the Justice Department. (Flamm, 1987, p. 116)

2. Standards

"Government measures to promote particular computer standards have significantly influenced the ground rules for competition in the industry." (Flamm, 1987, p. 118) The Brooks Bill of the late 1960s, combined with the increased responsibility of the National Bureau of Standards, began a move towards standardization throughout the industry. This eventually eliminated one significant barrier to entry, software lock-in (Brock, 1975, pp. 149-150). The COBOL

programming language, which evolved to become the defacto standard business computer language in the 1970s, is another example of a successful standards promoted by the government (Flamm, 1987, p. 119).

As the industry matures, the National Bureau of Standards is playing an increasingly important role, as industry players recognize the need for standardization among the hardware and software segments. "Private firms have increasingly begun to work with the National Bureau of Standards to define standards when they have lacked enough influence to impose their own designs." (Flamm, 1987, p. 119)

3. International Trade

"Access to foreign markets can be critical to the economic health of a particular company or to an entire segment of the technology industry, while foreign competition can be the single most significant threat to a domestic concern." (Nimmer, 1985, p. 8-2) The foreign dominance of the home electronic industry today exemplifies this notion, and causes the United States government and the U.S. computer industry to question whether the future computer industry will follow the same trend.

In computer technology, two broad international issues are at stake: national military security and the policies of other countries in promoting commercial growth in the computer industry. This study will focus on the later. The key issue

in evaluating the policies of other countries is determining whether their policies meet the U.S. definition of fairness in the marketplace, compared to the perception of U.S. policies. (Nimmer, 1985, p. 8-2).

In the computer industry today, Japan, who is competitive in every market segment of computer manufacturing, is the target of most government actions concerning international trade. While the government and firms in the computer industry generally encourage free trade, both the government and U.S. industry are quick to raise questions and take action against strategies that violate the U.S. perspective of fairness.

In September 1991, the General Accounting Office (GAO) confirmed complaints from the U.S. Electronics Industry that many Japanese suppliers withheld advanced technology from U.S. producers, while providing the knowledge to Japanese competitors. GAO's report revealed that "22 of the 59 U.S. concerns interviewed gave specific examples of Japanese companies rejecting orders for state-of-the-art equipment or parts, delaying delivery by six months or longer." (Lachia, September 25, 1991, p. B3). Such delays, in an industry that survives on fast-paced deployment of technology, could give Japanese firms unfair competitive advantages. (Lachia, September 25, 1991, p. B3)

Another prevalent foreign strategy in the international computer industry of today is that of dumping

products in the market place. By dumping products (selling them below cost), foreign firms attempt to undercut competitors' prices to increase market share (Nimmer, 1985, p. 8-5).

To combat foreign strategies that are deemed unfair, the government can impose duties, tariffs, or take other actions to attempt to protect U.S. concerns. (Nimmer, 1985, p. 8-2). The government's use of these powerful trade weapons; however, can have adverse impacts on the industry as a whole. A recent case in the U.S. laptop industry illustrates this point.

In August 1991, the International Trade Commission authorized steep antidumping duties (62%) on Japanese supplies of one of the most valuable types of flat screens used for laptops. These active-matrix, liquid crystal displays are expected to become the industry standard for the next generation of laptop computers. In imposing these duties, the Commerce Department lost sight of the big picture. They protected U.S. screen makers at the expense of the U.S. laptop industry because they failed to impose duties on finished laptops that contain the technology (Magnusson, December 2, 1991, p. 38-39).

These duties also had adverse side-effects on the U.S. economy, as laptop computer makers rushed offshore to begin laptop production. Toshiba, Apple and IBM are among the companies that have established laptop production overseas.

The increased support lines of these firms, extending over thousands of miles, have also increased the costs of overseas production. (Magnusson, December 2, 1991, pp. 38-39)

This situation replays the semiconductor controversy of the mid 1980s. While Japan's agreement to voluntary import restrictions in 1986 assisted U.S. semiconductor manufacturers, Japan continued to import complete computer systems at more competitive prices. Because U.S. computer manufacturing firms relied more on higher priced U.S. chips, it was more difficult for the U.S. computer industry to compete with Japanese systems. As a result, U.S. computer manufacturing firms suffered in the U.S. and overseas. (Ferguson, July-August 1990, p. 64, 66)

Though foreseeing secondary and long-term impacts such as these are complex in today's changing computer industry, such forethought is essential in protecting the U.S. computer industry. While government and industry leaders' views differ on the tradeoffs between trade protection and free trade, more cooperation and coordination between the government and the computer industry is essential in competing in the global computer industry of today and the future.

VII. STRATEGIES OF THE 1990s

A. Overview

The computer industry of the mid 1980s was perhaps at the peak of its growth. The advent of the personal computer changed the structure of the industry, opening new markets and providing new opportunities to leading industry players and small upstarts. This growing industry was hailed as the model of U.S. industrial success and was characterized by double digit profit margins and expansion. The computer industry of the 1990s, however, is approaching maturity. Major technological advances, such as the PC, have transformed to fast-paced enhancements and the computer has become a mass-produced commodity. This maturity, combined with the squeeze of recession, has forced even the major firms in the computer industry to rethink their strategies for the decade ahead. This study will look at these strategies of change and identify the underlying reasons for the changes.

B. Reorganizing and Downsizing

In 1985, the computer industry suddenly experienced a decline in annual growth rate, from 15% to 9%. The industry as a whole, however, was not alarmed. The largest computer manufacturers viewed this change in growth as a temporary slump that would be renewed by new technological advances and

the ensuing opportunities. While the industry did rebound in 1988, the growth rate was far lower than that of the early 1980s, forcing profit margins to shrink from double to single digit figures. Confronted with this decline, firms such as IBM, Unisys, and Groupe Bull trimmed payrolls and closed marginal facilities in a calm, controlled manner. (Verity, August 19, 1991, p. 106)

The controlled cutbacks of the late 1980s transformed into an industry-wide frenzy of restructuring, downsizing and revamping in the midst of the recession of the early 1990s. While the decline in demand for computers, brought by the recession, was a contributing factor, the underlying reasons for these shifts in strategy are far deeper.

1. A Commodity Item

The primary reason for the turmoil in the computer manufacturing industry of the 1990s lies in the fact that the computer is now a commodity. Charles White, vice-president for industry service at Gartner Group Inc., likens the state of the computer manufacturing industry today to the automobile industry of the 1920s. He states, "computer hardware, like the automobile in the 1920s, has changed from a custom-built luxury item to a mass-produced commodity." (Verity, August 19, 1991, p. 106) Except for the biggest machines (that may soon be replaced by clusters of powerful smaller machines), computers are becoming commodities that customers buy as

cheaply as possible. With the excess capacity of computers around the world today, customers have the power to play computer makers against one another to get the lowest price (Bulkeley, September 5, 1991, p. A1, A6).

In addition to excess capacity, ceaseless, fast-paced innovation in every segment of the industry has driven prices down further, resulting in low profits. According to Technology Research Corporation, "over the past five years, profit margins for the 11 largest U.S. computer companies average just 6.5%; in the previous five years, they averaged 11.5%." (Bulkeley, September 5, 1991, p. A1)

The recent history of the computer industry outlines how the computer became a commodity. The PC was the first computer to become a commodity, as the pseudo-monopolies of Intel and Microsoft sold their technologies to all comers. The commodity battlefield is now expanding to the more expensive, sophisticated workstation segment (Bulkeley, September 5, 1991, p. A1). As linked super Pcs and workstations harnessed computing power comparable to mainframes at a fraction of the cost, the minicomputer and mainframe markets of the industry also fell victim to commodity pricing.

The fact that the computer is now a commodity has dramatically changed the industry. Many companies that prospered in the 1980s are now scrambling to reinvent how to do business just to survive in the 1990s (Bulkeley, September

5, 1991, p. A1). "Analysts predict that commodity pricing will keep plaguing the companies until their number has dropped considerably." (Bulkeley, September 5, 1991, p. A1)

2. Cracking Cultures

A major trend in reorganization strategies throughout the computer industry is the attempt to crack the existing culture and bureaucracy that was built during the growth of past decades. By cracking the stifling bureaucracy, firms hope to gain the flexibility needed to better take advantage of the small windows of opportunity in today's fast-paced industry. Notes one analyst, "getting to the market first with new technology, above all, is the name of the game." (Schwartz, December 16, 1991, p. 114)

IBM's strategy for the 1990s illustrates this approach to restructuring and downsizing, and exemplifies the problems of trying to reorganize a bureaucratic giant. In what Chairman John Akers called a "fundamental redefinition" of the business, IBM conducted a top to bottom shakeup "to clear out the deadwood, 'empower' the remaining workers, and finally begin the process of restoring Big Blue's luster." (Schwartz, December 16, 1991, p. 113) In the process of this shakeup, IBM cut 20,000 jobs, added to 53,000 job cuts since 1987 (Schwartz, December 16, 1991, pp. 113-114).

Akers' vision of the new IBM resembles a holding company with a decentralized corporate structure that pushes

authority and responsibility for decision-making to autonomous business units. With this strategy, Akers hopes to give independent managers the power and leeway, previously held by headquarters, to better respond to the accelerating pace of change in the industry. With this increased authority, however, comes accountability. Managers will have increased responsibility for unit performance, ultimately assuming the profit-and-loss responsibility now held by headquarters. (Schwartz, December, 16, 1991, p. 113) This strategy "spells the end for the Big Blue cocoon, an organization that insulated most managers from unpleasant details, such as profit-and-loss statements, and kept them employed even when their performance was mediocre." (Schwartz, December 16, 1991, p. 113)

While IBM supporters are praising the plan, skeptics, including Wall Street as a whole, caution that restructuring IBM's ingrained corporate culture is an effort that will take years of reprogramming (Schwartz, December 16, 1991, p. 113). Management consultant Tom Peters warned that "corporate culture has more to do with the mind than the organization chart." (Schwartz, December, 16, 1991, p. 113) Other skeptics feel that "no matter how sincere Akers' intentions are now, he and other people molded by lifetimes at IBM may not be equipped to create a truly new Big Blue." (Schwartz, December 16, 1991, p. 118)

Like IBM, other computer manufacturers, including Digital Equipment Corporation (DEC), Unisys, Hewlett Packard (HP) and Compaq, have taken drastic measures, downsizing and attempting to rid themselves of bureaucratic overhead.

In July 1991, Unisys announced a 14% reduction in work force (equating to 10,000 job cuts), and a move to narrow its focus in the mainframe market (Carroll, July 24, 1991, p. A3).

In October 1991, Compaq dismissed about 1400 people (about 12% of its work force) in an attempt to "slash company costs, introduce products more quickly, and sell through more distribution outlets." (Bartimo, November 6, 1991, p. A3). In conjunction with the cutbacks, Compaq planed to make major changes in the current management structure, described by new CEO Eckhard Pfeiffer, as being "unfocused and too slow to let the company react to fast changes in the computer industry." (Bartimo, November 6, 1991, p. A3)

While most of the major firms have yet to see the benefits of their new strategies, a 1990 reorganization at Hewlett Packard (HP) was already paying off. In June 1990, HP lost share in critical computer markets after delaying new machines. Like most large firms in the computer industry today, "HP was suffering the classic symptoms of corporate gigantism: slow decision-making, sparring fiefdoms, and an uncontrolled cost structure." (Yoder, July 22, 1991, p. A1) As HP's orders, earnings, and morale fell in each quarter of 1990, CEO John Young began a series of changes, culminating in

a major reorganization in October 1990. Young eliminated excess layers of management and put product development in the hands of leaders with proven ability to cut through red tape. He also combined computer-product groups together according to the way they are sold and restructured HP's sales force to solve marketing problems. (Yoder, July 22, 1991, p. A1)

Within six months of HP's reorganization, profits rose, HP stock more than doubled, and the company introduced two impressive new computers, including a workstation that set new speed standards (Yoder, July 22, 1991, p. A1). In commenting on the reasons for his company's reorganization, Young stated "we didn't want to be caught in the big-company mentality where you can't get anything done...like companies I can't mention that have blue products." (Yoder, July 22, 1991, p. A1)

3. Computer Technology

A contributing factor in computer firms' ability to downsize and reorganize is the industry's own use of computer technology. By incorporating the same powerful, innovative technologies they build into their management structure, computer manufacturers give remaining managers the power to handle higher workloads. Local area networks (LANs) allow companies to cut costs by sharing resources. Networks also allow groups of developers to exchange ideas more easily, cutting product development time. Thus, the use of

information technology within management structures of computer firms provides a way to help firms reach the new vision of organizational structure for the computer manufacturing industry in the 1990s.

C. Strategic Alliances and Consolidation

While internal downsizing and reorganization strategies may cut costs and maintain a profit in the short term, these strategies alone will not be enough to carry firms through the 1990s. As the computer industry matures, it is exhibiting the traits of other more mature industries. Today's slow economy helps to speed the maturity of the computer industry, keeping a lid on demand for computers and fueling commodity pricing. These trends are leading to a major shakeout in the computer manufacturing industry, in which the *strong shall devour* the weak. In this maturing industry, firms are turning towards strategies of alliance and consolidation in order to survive.

This portion of the study will view the recent history of strategic alliances in the computer industry, the forces behind the increasing number of alliances in the industry today, and the goals of these alliances. Similarly, the study will look at the rising trend of consolidation in the industry today and compare this trend to consolidation in other industries. Finally, the study will compare these alliance and consolidation strategies to keiretsu, Japan's industrial

network, to determine the future of the U.S. computer manufacturing industry in the increasingly global market.

1. Strategic Alliances

While alliances in the computer industry of the 1980s were characterized by lackluster results, constant disagreements, and often bloody lawsuits, the nature of the industry in the 1990s is forcing even the major powers to align in order to survive. Firms have discovered they can no longer develop new, competitive technologies solely on their own. "Survival of the fittest is now a matter of who cultivates the best relationships with the strongest partners." (Coale, July 22, 1991, pp. 44-45)

a. Alliances of the 1980s

The most publicized alliance of the 1980s was between IBM and Microsoft. Spanning the entire decade, this alliance was probably the roughest in the industry and included the two companies that defined the PC market.

The pact began in 1980 when IBM asked Bill Gates, co-founder of a 32 man upstart called Microsoft, to develop an operating system for the original IBM PC. Gates delivered a year later, introducing MS-DOS. As the IBM PC and MS-DOC became the PC industry standard, clones quickly appeared on the scene, undercutting IBM's prices and damaging their lead in the PC market. (Brandt, October 1, 1991, p. 164)

In an attempt to fend off the clones, IBM began a make or break plan in 1985 to recapture its lead in the exploding PC market. It centered on the development of a more proprietary operating system for personal computers named OS/2. While IBM attempted to cut their ties with Microsoft in 1985, an appeal from Gates reversed that decision and began the saga of OS/2 between the two companies. (Carroll, December 2, 1991, p. A1)

The two companies' ideas on the development of OS/2 differed drastically. Microsoft developed the system from a PC perspective while IBM had a mainframe view. These differing perspectives, combined with IBM's bureaucratic ills, resulted in a development process with 1700 programmers working at three sites on two continents. (Carroll, December 2, 1991, p. A14) "The result: a product far too complicated for mere mortals to use; far too big to run on many of the computers that IBM introduced together with OS/2 in April 1987; and far too revolutionary." (Carroll, December 2, 1991, p. A14) To even convert to OS/2 would require many users to reinvest in a complete new package of hardware and software (Carroll, December 2, 1991, p. A14).

These problems prompted Microsoft to return its focus to its Windows graphical interface, promising Windows as an interim step that would eventually lead customers to OS/2. Microsoft's promises continued in a key meeting in November of 1989, as IBM agreed to endorse Microsoft's Windows for low-

powered Pcs in return for Microsofts's agreement to make writing OS/2 a top priority. In May 1990, the software industry saw a strong push for Microsoft's Windows 3.0, with little progress in OS/2's development. IBM viewed Microsoft's move as an appalling abandonment of OS/2. (Carroll, December 2, 1991, p. A14) In November 1990, the two giants parted in a computer industry version of divorce court (Coale, July 22, 1991, p. 45).

Since the split, Microsoft has continued to fatten their profit margin with Windows sales. Meanwhile, IBM, probably the only computer firm with pockets deep enough, took charge of OS/2 (Carroll, December 2, 1991, p. A14). After embarrassing delays, IBM finally delivered OS/2 (Version 2.2) in a December 1991 limited product preview. They claim this version will run circles around Windows. This version will be fully available in March 1992. (Semich, 1 December, 1991, p. 27) The question now is whether IBM can convince customers that OS/2 is good enough to switch from Microsoft's entrenched Windows program.

Other alliances in the 1980s resulted in similar outcomes. Ties between Microsoft and Apple in the mid 1980s resulted in Apple's 1988 suit against Microsoft, claiming that Microsoft's Windows 2.03 infringed on the Macintosh operating system. The suit, which centers on the controversial "look and feel" of a program goes to trial in June 1992. In an unproductive effort, IBM and Lotus began a joint effort in

1987 to deliver an SQL database. While the two firms managed to stay out of court, the database never materialized. (Coale, July 22, 1991, p. 45)

b. Alliances in the 1990s

Although alliances in the computer industry of the 1980s did not have a good track record, virtually every firm in the industry has forged closer ties to combat the forces in the computer industry of the 1990s. The motivations behind these numerous, seemingly random alliances vary. The bulk of alliances are geared to winning the desktop war of the 1990s, as firms exchange technologies on super PC and workstation projects. Other alliances are focused on establishing standards for the future. A third motivation centers on establishing ties to better tap the global market and better integrate other technologies that are merging with computers.

While not an all-inclusive list, Table 79 through Table 82 provide a synopsis of the major alliances and joint ventures in the computer industry through January 1992. Analyzing the focus of these alliances illustrates the intent of the players involved.

The most powerful and most unthinkable alliance in the industry was forged in the summer of 1991 between IBM and Apple and has already changed the structure of the industry. The two leading personal computer makers agreed to combine efforts to better compete in the huge desktop market of the

1990s. Joint venture plans include research and development efforts, the exchange of RISC chip technology, and the development of an advanced operating system that will marry the hardware of the two companies. While competition in the PC and workstation markets is probably the primary motivation of the IBM-Apple alliance, a related motivation is to decrease Microsoft's strong hold on the PC software market. Many observers point to Microsoft and Bill Gates' aggressive attitude over the past years as the cause of IBM's recent deal with Apple. (Coale, July 22, 1991, pp. 44-45)

The stunning alliance between IBM and Apple triggered a series of alliances and joint ventures throughout the industry, spanning the globe and encompassing the technologies merging into the computer industry of the 1990s.

The IBM-Apple pact even has Bill Gates sweating, prompting Microsoft to make its own power moves while trying to downplay the existing animosity between Microsoft and IBM. In September 1991, Microsoft quietly expanded its ties with Intel and Digital Equipment Corporation (DEC), the nation's second largest computer maker, and again focused on competition in the desktop market of the future (Wall Street Journal Staff, December 3, 1991, p. B4). The alliance later announced the development of a new workstation that will use RISC chips to run Microsoft's new operating system, Windows NT. Use of this operating system will allow the workstation to run the thousands of existing PC programs, breaking down

the wall between Pcs and workstations and keeping Microsoft's application software market booming (Wall Street Journal Staff, December 3, 1991, B4). Gates is concurrently talking with top executives at IBM "about ways to repair the tattered relationship between the two companies." (Zachary, November 18, 1991, p. B1) While Gates' peace offering is admirable, its motivation is probably out of fear rather than goodwill.

Other alliances in the industry, including IBM's ties with at least five foreign firms, are attempting to establish foreign ties to better compete on a global scale.

Perhaps the only really strategic alliances, other than the IBM-Apple pact, are the consortiums geared towards setting industry standards in hardware and software compatibility. The "open systems" movement, established in April 1988, includes Sun, AT&T and Unisys, and is focused on setting workstation standards centered on Sun's SPARC workstation line and AT&T's Unix operating system (Myers, July 5, 1991, p. 6B).

The Open Systems Foundation (OSF), established in the fall of 1988, united DEC, Hewlett-Packard (HP), IBM and others "to develop an open Unix platform in response to AT&T's unwillingness to modify its Unix operating system to their needs." (Coale, July 22, 1991, p. 45)

A third alliance focused on setting standards for workstations is the Advanced Computing Environment (ACE). This consortium, led by Compaq and including DEC, Microsoft

and MIPS Computer Systems Inc., completes the power alignments of the major players in the industry. (Myers, July 5, 1991, p. 6B)

2. Consolidation

A step beyond strategic alliances and joint ventures is the rising trend of consolidation in today's computer industry. As the computer industry matures, it is moving from a price taker market towards an oligopoly. In a price taker market, characterized by the industry in the 1980s, no one firm has the power to alter the price it receives for its product. Price taker firms sell a small share of the market and sell a homogeneous product. In contrast, the maturing industry of the 1990s is moving towards an oligopoly, in which three or four large firms supply the major share of the market. (Peterson, 1991, p.229, 261) The recent acquisitions and mergers in the computer industry, outlined in Table 83, exemplify this move.

In September 1991, AT&T, creator of the Unix operating system, acquired NCR, a high-end computer company. Barely two months later, NCR acquired Teradata in a stock swap valued at $520 million. Teradata, by pioneering a computing technology called "massively parallel processing," offers an expertise injection to NCR. (Keller, December 3, 1991, p. A3) Combined with the communications support of AT&T, NCR Chairman Gilbert Williamson called Teradata's acquisition "a logical step that

will help ensure NCR's global leadership in enterprise-wide information systems and services." (Keller, December 3, 1991, p. A3) While this merger centered on the computer industry, the companies involved also have clout in the communications and software industries, forming an entity that mirrors the merging of technologies in today's information products. Future consolidations in the computer manufacturing industry will probably follow this trend towards well-rounded companies, as firms attempt to harness the power of constantly merging technologies in the industry.

Consolidation is even more prevalent in the software development industry, as the little guys join forces to battle with the Microsoft empire. In August 1991, Computer Associates (CA), the Avis of the pure software companies, acquired On-Line Software for roughly $120 million, marking CA's first big purchase since its 1989 acquisition of Cullinet Software (Carroll,August 19, 1991, p. B3). Two weeks later, CA stepped up its acquisition strategy, agreeing to purchase Pansophic Systems Inc. for $290 million (Fuchsberg, September 4, 1991, p. A5).

Other key acquisitions in the software development industry in 1991 included Novel and Digital Research's $80 million merge, and Ashton-Tate and Borland's pact, valued at $440 million (Bremner, October 14, 1991, p. 87).

As in the computer manufacturing industry, these software acquisitions exemplify a trend towards well-rounded

firms, as companies with complementary products merge to form an entity better able to compete in the diverse software industry.

3. The Age of Consolidation

Consolidation and alliances are far more prevalent in other more mature U.S. industries. Looking at these industries can offer further insight about the forces moving the U.S. as a whole towards consolidation. The precedents set in these other industries can also help in predicting the future structure of the computer manufacturing and software development industries.

The Age of Consolidation began during the deals of the late 1980s, "which left tires, airlines, and appliances in the hands of virtual cartels." (Bremner, October 14, 1991, p. 87) By 1991, the top five firms in tires, airlines, and appliances controlled 66%, 75%, and 97% of the industry market share respectively. While such dominance by so few would have "set off antitrust alarm bells" (Bremner, October 14, 1991, p. 86) a decade ago, today these megamergers go almost unnoticed. The Justice Department's muted reaction to this flood of consolidations illustrates the government's expanding concerns not with just "ensuring domestic price competition, but with bolstering U.S. global competitiveness." (Bremner, October 14, 1991, p. 88) A decade ago, there was a general fear of the power of American business, leading to such events as the

breakup of AT&T in 1982. Today, the fear is of America's weakness in the global marketplace. (Bremner, October 14, 1991, p. 88). Michael Porter, a professor at the Harvard Business School, notes that "much of the drive toward consolidation and mergers is generated out of (this) fear" (Bremner, October 14, 1991, p. 89). In the face of this fear and the increasingly global computer market, the computer industry, like other more mature industries, will probably see more consolidation, moving towards an oligopoly.

4. The U.S. Computer Industry and Keiretsu

The final portion of this chapter compares the computer industry today to Japan's industrial-financial groups called keiretsu. Using Charles Ferguson's Harvard Business Review article, "Computers and the Coming of the U.S. Keiretsu" as a guide, this study shows how recent developments in the computer industry have moved U.S. computer companies toward the keiretsu concept (Ferguson, July-August 1990, pp. 55-70). The study also analyzes the views of computer industry leaders on what actions the U.S. government and computer industry players must take to preserve U.S. competitiveness in the computer industry of the future.

a. Definition of Keiretsu

Japan's keiretsu, or societies of business, take two major forms.

> Bank-centered keiretsu are massive industrial combines of 20 to 45 core companies centered around a bank;

> they enable companies to share risk and provide a mechanism for allocating investment to strategic industries. Supply keiretsu are groups of companies integrated along a supplier chain dominated by a major manufacturer. (Ferguson, July-August 1990, p. 58)

The companies in keiretsu are interlocked at all levels. Group members typically practice mutual shareholding by purchasing a small amount of each others' shares and agreeing not to sell them. This mutual shareholding accounts for 15% to 30% of member companies' stock. (Ferguson, July-August 1990, p. 59) "Including 'stable shareholding' agreements with other large institutions, some 60% to 80% of keiretsu company shares are never traded, so managers do not have to worry about takeovers and can focus on long-term issues" (Ferguson, July-August 1990, p. 59). This alone differs greatly from the short-term, corporate raider mindset in U.S. business.

The interlocking nature of keiretsu, however, offers more advantages through vertical and horizontal linkages, running several layers deep.

> The keiretsu system thus combines horizontal scale, diversified production of related systems, vertical technical coordination, and market discipline. Each sector-particularly critical components and capital equipment-is concentrated but not monopolistic, thus guaranteeing stability and scale while preserving internal rivalry. (Ferguson, July-August 1990, p. 63)

The Japanese government's role in keiretsu also has a major impact on its success. Its active encouragement for the concept of keiretsu dates back to the pre-World War II era and was largely responsible for Japan's military machine. After the war, U.S. occupation broke up the few strong groups,

but by the mid 1950s, the same companies began to reassemble behind the core banks. (Ferguson, July-August 1990, p. 58)

Today, Japanese government intervention is almost non-existent, playing a much different role than the antitrust prone U.S. government. Japan's semiconductor market illustrates the extent of government intervention in computer manufacturing. "There is no need for the Japanese government to intervene to protect the domestic semiconductor market when six Japanese companies with deep, long-standing relationships account for more than 80% of Japanese computer production." (Ferguson, July-August 1990, p. 64)

The advantages of keiretsu are considerable. The trust, vested interests, and sharing of resources and information among the companies diffuse the huge costs of research and development, promote cooperation and restrain the cut-throat competition that has been so prevalent in the U.S. Japan's dominance of home electronics, a technology now merging with computer technology, illustrates the power of keiretsu in action. (Ferguson, July-August 1990, p. 64)

b. Threats to the U.S. Computer Industry

In addition to the power of Japan's keiretsu, other factors in the computer industry of the 1990s may further weaken U.S. manufacturers' ability to compete in the future.

A major threat is the present dependence U.S. companies have on Japanese producers for critical system

components. Japan's dominance of the DRAM semiconductor market of the late 1980s and current hold on state of the art liquid crystal displays for laptops are two examples of this dependence. By regulating production of these components and withholding the technology, Japan caused severe supply shortages in the U.S., stalling the computer manufacturing industry. Concurrently, in both cases, Japanese computer companies manufactured computers containing these new technologies and sold them in the U.S. at very aggressive prices, decreasing the market share for U.S. companies. (Ferguson, July-August 1990, p. 64) Continued dependence on Japan for critical components may find U.S. computer firms at the mercy of Japan's proven tactics.

A related threat to the U.S. computer industry is the digitization of virtually everything.

> Previously unrelated industries-cameras, computers, stereos, photocopiers, typewriters-are converging to form a huge, unified information technology sector, itself based on common digital components and standard interfaces. Increasingly, competition in all kinds of hardware is driven by the same new logic governing competition in computers-growing commoditization of product markets and growing advantage for companies with superior components technologies, manufacturing system, and strategic leverage. (Ferguson, July-August 1990, p. 56)

Such digitization plays directly into the strategic and technical strengths of Japanese companies, proven already in the home electronic industry. The fact that many of these companies are embedded in keiretsu gives them profound advantages in access to the huge capital needed for success,

allowing them to focus on the long-term. (Ferguson, July-August 1990, p. 56) Multimedia will probably be the first major battle over digitization in the computer industry. The outcome of that battle will probably impact heavily on the future U.S. role in the computer industry.

Another problem in the U.S. computer industry of the 1990s, as well as other industries, is the government's role in the U.S. economy. Our nation has an historic distrust of corporate bigness dating back to John D. Rockefeller's oil empire and J.P. Morgan Sr.'s banking and railroad dominion. In past years, U.S. antitrust laws have controlled such distrust by breaking up potential powers in order to protect the healthy effects of domestic competition. (Bremner, October 14, 1991, p. 88) In today's maturing computer industry, such control mechanisms handicap U.S. computer firms in competing in the global marketplace.

A final key problem is that U.S. firms do not have the low interest, capital assets that the core banks of keiretsu provide to their members.

c. Moves to Turn the Tide

The onslaught of alliances and consolidations in the computer industry is an indicator of things to come. The current picture of these alliances and consolidations illustrates the movement of the computer industry towards a U.S. version of keiretsu. Figure 14 combines the alliances

and consolidations outlined in Table 79 through Table 83, to provide a snapshot of computer industry relationships today. Compared to past decades, these ties are far more numerous, more global, encompass more technologies, and are increasingly stronger.

d. Future Actions

While the ties of the U.S. computer industry are promising, industry leaders feel that a coordinated effort from the U.S. government and the industry will be required to preserve U.S. competitiveness in the future. A primary area for action is in modifying U.S. antitrust laws to better foster the concepts of keiretsu. Lester C. Thurow, dean of the Sloan School of Management at the Massachusetts Institute of Technology (MIT) notes, "in the long run, we probably need to adjust our antitrust laws to allow companies to set up huge business groups." (Bremner, October 14, 1991, p. 88)

Actions in the computer industry must focus on increased cooperation and responsible competition to decrease the U.S. computer industry's reliance on Japan, and to market products more effectively and efficiently. "Only by cooperating as they compete will U.S. companies be able to rationalize major components sectors, maintain a technically competitive, non-Japanese capital-equipment and components supply base, and create long-term, reciprocal partnerships

U.S. COMPUTER KEIRETSU

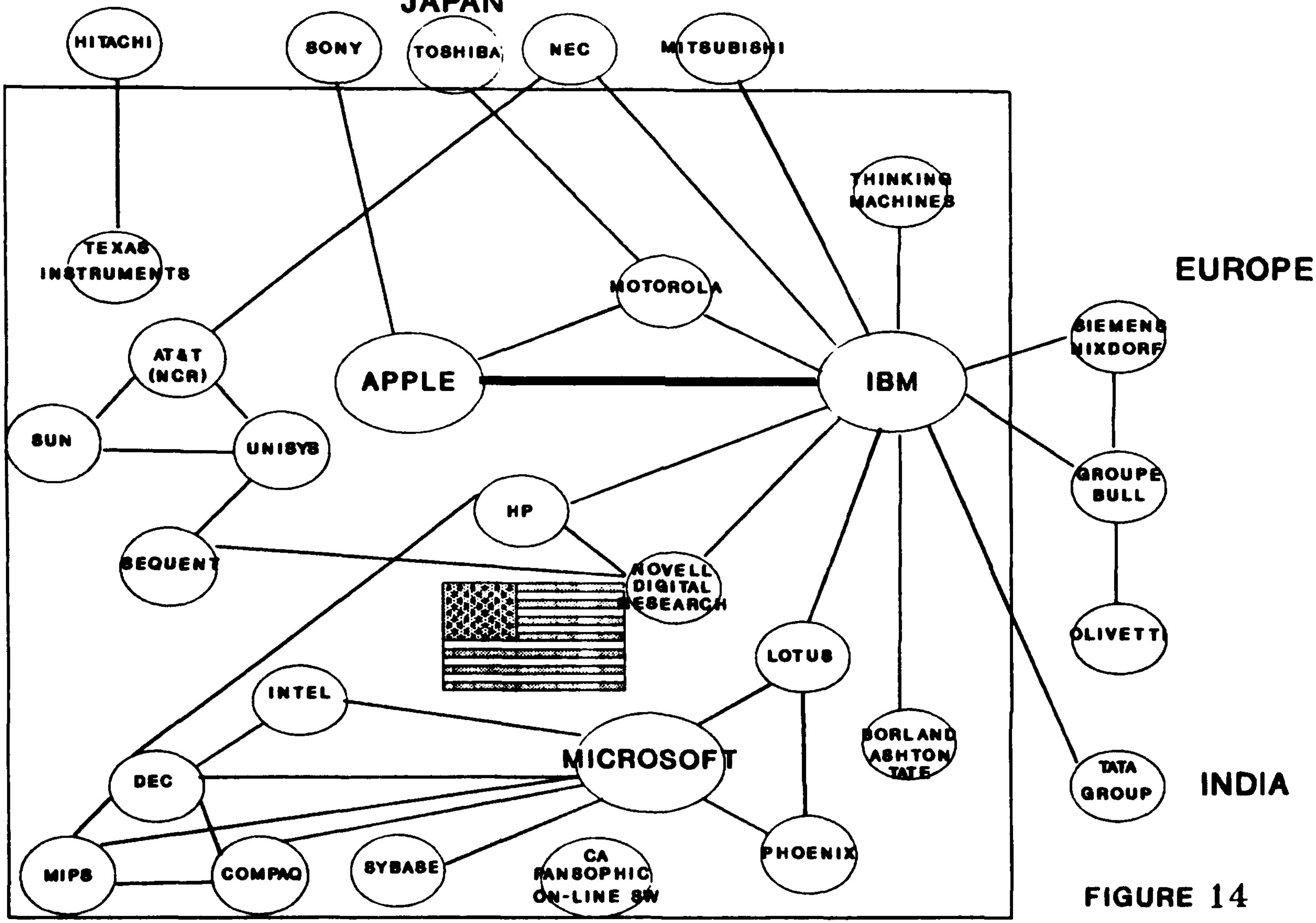

FIGURE 14

between innovative designers, standards developers, large-scale manufacturers, suppliers, and distribution channels." (Ferguson, July-August 1990, p. 70)

Such a coordinated effort will be a complex but necessary task to ensure U.S. competitiveness in the computer industry of the 1990s.

VIII. FORECAST OF THE COMPUTER INDUSTRY

A. Overview

While accurate, detailed predictions in the fast-paced environment of the computer industry are difficult, the emerging trends of the late 1980s and early 1990s provide a basis to forecast the structure and forces of the industry through the 1990s. This portion of the study provides a forecast of the industry by extending these trends through the turn of the century. The study views how the forces in the computer industry affect the values, markets and strategies of the 1990s. The study will close by forecasting how these changing forces will reshape the future markets of the industry and predict the firms with the power and forethought to lead these markets.

B. Reliance on Strategic Alliances

The strategic alliances and consolidations formed in the computer industry during the late 1980s and early 1990s will play major a role throughout the rest of the decade. While the strengthening of ties was, in part, a response to the woes of the recession, the motivations for the ties are deeper. Throughout the 1990s firms will rely more heavily on these ties to muster the power to compete in the fast-paced, complex, global computer industry. Unlike the success of the

"garage entrepreneurs" of the early 1980s, small firms without allies in the 1990s will either die or be sucked up by the strong.

Even the booming software development industry will experience this type of Darwinian shakeout and realignment. As the strong software firms set the standards for the industry, the weak must either conform and cooperate or perish. "Survival of the fittest is now a matter of who cultivates the best relationships with the strongest partners." (Coale, July 22, 1991, pp. 44-45) Thus, the computer industry of the 1990s will be an industry characterized by expanding, strengthening power alignments.

C. A Focus on Value

Another overriding trend in the computer industry of the future will be a shift in focus towards value - value of information and value in computing. These shifts will impact directly on the structure of the industry and may set the stage for a U.S. power surge in the computer industry.

1. Value of Information

Technological innovations in the computer industry in the past decades have markedly increased the user's ability to gain access to more information, in an increasing number of ways, at ever-increasing speeds. The human mind, however, has a limit to the amount of information it can digest. At some point, information reaches the point of diminishing returns.

Today's innovations contribute to this information overload through the use of such technologies as E-Mail, modems, fax machines, laptop computers, networks, and cellular phones. The end result is an information squeeze on the user Just because the cost of information is decreasing, does not mean that the value of information is increasing (Barron, May 1991, p. 170). As a result, users and the computer industry as a whole are finding ways to prioritize information based on its value. (Hirsch, August 12, 1991, p. B1)

For users, one of the hottest trends to get more value from information is through re-engineering. While the idea of re-engineering seems painfully simple, it is one that has been overlooked or ignored in past decades. The process entails breaking down business functions to the lowest level, then rebuilding the functions, automating only when necessary (Verity, July 22, 1991, p. 66). Even the Department of Defense is turning to re-engineering with its Corporate Information Management (CIM) initiative.

Users who have undergone this re-engineering process have seen better productivity gains from computer investments than they have seen in years. James F. Moore, president of Geo-Partners Research Inc., a re-engineering consultant company, claims that the re-engineering is "reducing costs by 80%, improving time to market by 80%, or doubling sales." (Verity, July 22, 1991, p. 69)

Computer makers hope that such productivity gains from computer investments, which have dwarfed the promised benefits of automation in past decades, will spur new sales. Re-engineering will also expand the computer services market segment, from a 5.4 billion segment in 1990, to one that will hit an estimated $14.6 billion in 1995. (Verity, July 22, 1991, p. 66)

Computer products of the 1990s will mirror the user shift towards information value, using technology to overcome the current flood of information users face today. "Multimedia" PCs will help users prioritize and organize information in written, graphic and voice form." (Hirsch, August 12, 1991, p. B1). Additionally, Ultra-compact PCs, using voice input and output, will act as portable planning tools and information centers (Brandt, August 12, 1991, p. 60).

2. Value in Computing

While the computer industry's increased focus on the value of information will directly affect the product lines and the computer service market segment, an increased focus on value in computing has the potential to change the nature of the computer manufacturing industry.

In "The Computerless Computer Company," a recent Harvard Business Review article, the authors define the

concept of computing value and its application in today's computer industry.

> Value derives from scarcity. In the computer industry, scarcity now resides in the gap between power - what computers and their underlying semiconductor technologies are capable of doing - and utility - what human imagination and software engineering are capable of enabling computers to do. (Rappaport, July-August, 1991, p. 70)

Once this value is identified, power is achieved by creating a proprietary position and leveraging. The rise of Microsoft is a model of this creation of power.

> Microsoft thrives because it bridges the gap between power and utility, and it does so in a way that both maintains its proprietary position and leverages rather than replicates the massive capital investments made by less influential hardware companies. It understands that it is more rewarding to 'tax' the path between hardware production and consumption than to build hardware. (Rappaport, July-August 1991, p. 71)

Microsoft's products demonstrate this power. Its MS-DOS and Windows operating environments have become the distinguishing factors in computer purchases. "Customers have come to insist on MS-DOS or Windows computing," (Rappaport, July-August, 1991, p. 70) while they are largely indifferent to the hardware that delivers the environment. While this situation put Microsoft in a proprietary position, it was its exploitation of that position that developed the company into probably the most powerful company in the computer industry today. (Rappaport, July-August 1991, pp. 70-71)

Microsoft's primary exploitation strategy was to leverage its software advantage. A comparison between Apple

and Microsoft illustrates this leveraging and the changing nature of value in the computer industry. "Macintosh's most important advantage has always been its operating system - a software achievement whose technical virtues dwarf anything delivered by Microsoft." (Rappaport, July-August 1991, p. 71) Further, Apple beat Microsoft by six years in developing a graphical user interface (GUI) operating environment. With these marked industry advantages, Apple should be growing at a blistering pace, yet it is caught up in the same wave of downsizing and reorganization that is plaguing the bulk of the computer industry. Microsoft, on the other hand, a company whose profits rose 53% during the recession, is continuing to expand its empire. The reasons for Microsoft's dominance lie in its recognition of the changing value in computing and its leveraging. (Rappaport, July-August, 1991, p. 71)

While Apple defined its business as building computer hardware, Microsoft defined its business on dictating how computers are designed, built and applied (Rappaport, July-August 1991, p. 71). Windows 3.0 for example, "defines how millions of computer users expect to interact with their software and the coding environment in which thousands of developers write new applications" (Rappaport, July-August, 1991, p. 71).

This difference in strategies offered decisive leveraging advantages for Microsoft. "Microsoft was the only computer company that benefitted directly from global research

and development spending on computer hardware," (Rappaport, July-August, 1991, p. 71) as virtually every microcomputer manufacturer, except Apple, devoted capital to improve the platforms that run Microsoft's operating systems and applications. In contrast, Apple's proprietary system, though technically superior, benefitted only from Apple's research and development spending (Rappaport, July-August 1991, p. 71). This research and development burden was a major factor in Apple's alignment with IBM (Bremner, October 14, 1991, pp. 86-89). The proprietary nature of Apple's system also limited its influence to the comparatively narrow range of computers that Apple developed internally, while Microsoft entrenched its operating systems in the hardware of hundreds of manufacturers (Rappaport, July-August, 1991, p. 71).

Microsoft's rise to power exemplifies the changing value in computing that will prevail in the 1990s. This change in value brings with it new rules for industry competition:

- Compete on utility, not computing power.
- Monopolize the true sources of added value; create vigorous competition for enabling components.
- Maximize the sophistication of the value you deliver; minimize the sophistication of the technology you consume. (Rappaport, July-August 1991, pp. 77-79)

The most successful companies of the 1990s will adhere to these new rules of competition. "Defining how computers are used, not how they are manufactured, will create real value -

and thus market power, employment, and wealth - in the decades ahead." (Rappaport, July-August 1991, pp. 69-70) Though the most powerful computer companies will probably never give up on the notion of manufacturing computers as the authors of "The Computerless Computer Company" propose, manufacturers will shift their focus to defining how their products are used in addition to making them. This shift will serve to blur the line between hardware and software companies in the future computer industry.

For the U.S. computer industry as a whole, this shift in focus to value in computing has the potential to give U.S. computer firms the power surge it needs to compete in the industry of the future. Bridging the gap between power and utility plays directly into the strengths of U.S. companies, who currently lead the world in most of these technologies, including "microprocessor architectures, operating systems, use interfaces, databases, and application software" (Rappaport, July-August 1991, p. 70). While the current lead is not invulnerable, it does set the stage for U.S. power in the global computer industry of the 1990s. (Rappaport, July-August 1991, p. 70)

D. Innovation

In addition to the changing values in the computer industry, innovation is another major factor that will define the structure of the markets in the future. This portion of

the study will look at the major hardware and software technologies on the horizon and forecast how these technologies will shape the structure of the computer industry.

1. Hardware

The advent of the personal computer in the early 1980s was really the most recent radical, industry-shaking innovation. Since its introduction, innovations in the computer industry have taken the form of enhancements and improvements. Computer industry leaders, however, see a technology on the horizon that has the same potential as the PC, pen-based computing.

Pen-based computers allow users to write on screens, rather than type and are also as portable as clipboards, making their potential market huge. "Researcher BIS Strategic Decisions predicts that in 1995, when tablet computers have been refined, (pen computer) sales will hit $1.5 billion." (Zachary, October 17, 1991, p. B1)

While these notepad computers can provide the harried executive with a handy tool, the largest market consists of drivers, meter readers, and other workers who fill out forms as a large part of their jobs. Most workers in this huge market spend their day on the move. Many do not have the luxury of a PC, nor typing skills. (Zachary, October 17, 1991, p. B1) In this huge market, pen computers have the same

potential to change they way companies do business as the PC did in the early 1980s. Further, market surveys indicate that by 1995 over 30% of all PCs sold will be laptops, and half of the laptop computers sold will be pen-based (DCI, February 1992, p. 33). Ed Yourdon, CASEWORLD conference chairman and publisher of American Programmer, touts pen-based computing as "a new tidal wave that will have the same impact on our industry that PCs had in 1981." (DCI, February 1992, p. 33)

Multimedia is another major innovation sweeping the industry. Multimedia melds the technologies of television, compact discs, and personal computers into a product that "can do everything but walk the dog." (Brandt, August 12, 1991, p. 62) This technology has the potential to influence every existing low-end market segment, as well as expand segments, promising to help even the computer-illiterate play in the Information Age.

Currently, the most developed systems are custom-built for industrial training, education, and public information. Home systems exist, but are still evolving and carry hefty price tags. (Schwartz, December 16, 1991, pp. 130-131) Multimedia prices, however, are almost sure to drop as quickly as other systems' prices have in past years.

In viewing the future of the computer industry, multimedia merges yet another technology into the computer industry, bringing home electronics into the computer world. This technological merge is much like the convergence of

computers and communications in past years. The merge will require new standards to ensure compatibility among systems. Digitization will also play a heavy role in these merging fields. Companies that exploit the advantages of multimedia in the future will be those who set the industry standards that define how this technology will be used.

Most other innovations in the computer manufacturing industry of the 1990s will take the form of enhancements and improvements to existing technologies. These improvements, however, will continue at the blistering pace of today. Hardware will continue to offer more power at increasingly affordable prices.

The increasing pace of these improvements is also prompting innovations in more easily upgradeable hardware, as users struggle to combat obsolescence.

The industry will also see extensive enhancements in voice input and output, now a relatively crude, unexploited technology (Brandt, August 12, 1991, pp. 60-64).

In the networking arena, the industry will see a proliferation of technologies that connect PCs to wireless phone networks. Laptops will also have the capability to bounce signals off satellites. (Brandt, August 12, 1991, p. 61) "In the office, wireless versions of local area networks will replace the jumble of wires currently used to link PCs." (Brandt, August 12, 1991, p. 61)

2. Software

The potential of industry-changing innovations in computer hardware will prompt equally impressive software innovations. Software developement firms are already developing operating systems and applications for pen-based computers. While new pen-based applications will create billions in revenue, the biggest profits will go to the firms that develop a more sophisticated, proprietary operating system to handle the complexities of recognizing handwriting.

Similarly, multimedia sets the stage for software firms to define a new industry standard. Microsoft is engineering the capabilities to handle multimedia's new technologies into its existing Windows program, and will probably build the same capabilities into its new operating system, Windows NT. Other companies, like IBM-Apple and NeXT are betting on a whole new approach known as object oriented programming (OOP). OOP "involves building programs from interchangeable blocks of prefabricated computer code called objects" (Brandt, August 12, 1991, p. 62), and will help accommodate multimedia technology. (Brandt, August 12, 1991)

The advantages of OOP, however, go far beyond multimedia. OOP supporters tout this methodology as having the potential to transform the computer industry. They predict this new methodology will have the same impact on software as the microchip has on hardware. These simple, self-contained, reliable components increase the understanding

of designs, allow greater reuse, and simplify software maintenance and updates. The end result could offer huge savings in time and money and get software development out of its current overwhelming backlog. (Verity, September 30, 1991, pp. 92-100) "In an era when hardware is a commodity and software is the key competitive technology, computer makers that exploit object-oriented software best are likely to dominate the computer industry itself." (Verity, September 30, 1991, p. 94)

Other innovations in software will mirror the enhancements of the hardware sector, as software developers attempt to define the way increasingly powerful platforms are used. The 586s platforms of the future will use RISC technology. This will force a new standard operating system, because the chip does less work, requiring operating systems and application systems to do more. Microsoft's Windows NT is geared to accommodate this technology, while other RISC accommodating operating systems include Sun's Solaris environment, and the future Apple-IBM environment (Crabb, February 1992, p. 91). Those who set the new industry standard will have the same exploitation opportunity Microsoft had in the early 1980s with MS-DOS.

E. Other Shaping Forces

1. Government and Legal Action

The pending decisions on controversial computer issues and other future government actions, most of which are due this year, will serve to shape the future computer industry. This portion of the study reviews the upcoming decisions and actions and forecasts their impact on the industry.

In June 1992, the courts will finally decide on Apple Computer's four year old lawsuit against Microsoft and Hewlett-Packard, determining whether Apple's copyright extends to the "look and feel" of its software. The issue is so crucial to today's software market that any decision will be controversial. Given the extent that Windows applications have covered virtually every existing market niche, the Justice Department will probably determine that copyrights do not extend to the look and feel of software products. Such a ruling would be consistent with the court's 1989 determination in a computer manufacturing lawsuit between NEC and Intel. In that case, a federal judged ruled that competitors could legally duplicate the functions of a computer chip without infringement (Dwyer, May 22, 1989, p. 89). By extending this precedent to software, the court will maintain consistency and better serve the world's reliance and vested interest in Windows applications.

Another major patent law development that could shakeout the software industry, is due in August 1992. In March 1991, Commerce Secretary Mosbacher named 14 business executives to a commission challenged with providing the first major rewrite of the Patent Act in 40 years. Defining new rules for software patent protection was high on the list of priorities. The outcome of the Patent Act rewrite could drastically change the structure of the software industry, from an industry with hundreds of vendors to one with only a handful of the strongest survivors. (Schwartz, May 13, 1991, p. 106)

Among the worst fears of smaller software companies is that future patents will be granted for computer interfaces, "perhaps making it impossible to forge links between different computer brands without first paying royalties." (Schwartz, May 13, 1991, p. 106) Such an action would accelerate the industry's existing move towards an oligopoly, consolidating the software industry from hundreds to tens of firms by the end of the decade.

The computer industry expects to see another potentially industry-shaping decision from the Commerce Department in August 1992. This decision centers on future standards for high-definition television. Given the increasing trend towards digitization, the new television standards will probably jump to digital. Such a standard will give firms the ability to more easily merge the technology of

television with computer and communications technologies. This ability would provide competitive advantages for the U.S. computer industry in the rising multimedia market, a market currently influenced heavily by Japan's home electronics firms.

A final pending government action involves the Federal Trade Commission's antitrust investigation against industry giant, Microsoft. This investigation could lead to an AT&T-style breakup of Microsoft into two separate companies, an operating system company and an applications company. Though such a split is unlikely, the fear is still present. However, this fear is not voiced by Microsoft, a company that would probably continue to thrive despite a split, but from other less powerful industry leaders. These industry leaders fear that a decision against Microsoft would set a precedent in America's most successful industry, placing unnecessary burdens on the industry and decreasing global competitiveness in the future. (Rodgers, June 24, 1991, p. 39)

2. Standards and Compatibility

The resulting chaos of trying to integrate the proliferating computer systems during the PC revolution emphatically reinforced the need for standards in the computer industry. In addition to government actions to promote standards in the industry, industry leaders began to form consortiums in the late 1980s to develop a common set of

standards among hardware and software in the industry. These alliances and their proposed standards, while establishing common links, are attempting to do so in a way that makes these new standards proprietary and exploitable. The current battles over the new workstation and new operating system standards exemplify these motivations. The industry will probably have very few compatibility problems in today's technology, if any. However, future technologies, such as pen computing, voice activated systems, and multimedia, will create a whole new set of profitable opportunities to set new standards. The successful companies of the future, in this era of standards and open systems, will be those that close their systems, within the broad guidelines of standards, and create proprietary concepts in the technologies of tomorrow (Rappaport, July-August 1991, p. 78).

F. Changing Market Focus

The commodity nature of computers today, combined with the forces shaping the computer industry of tomorrow, are prompting computer firms to expand their market focus. Viewing the strategies and ties of computer firms today can help to forecast the "power markets" of the future.

As the computer industry becomes increasingly global, U.S. computer firms are developing strategies and establishing stronger foreign ties to target foreign markets. In a relatively rare display of teamwork, American PC makers are

waging a crucial battle to crack Japan's PC market. They hope to preempt the same outcome that the automobile and consumer electronics industries saw in past years (Schlesinger, July 17, 1991, p. A1, A6). Led by IBM, Apple, and Compaq, American computer makers believe that a successful invasion will keep foreign rivals "from using home turf as a global springboard." (Schlesinger, July 17, 1991, p. A6)

Another shift in market focus, primarily geared to encompass the technologies of multimedia, is a move into the home electronics market. Japan's current dominance in the home electronics market could seriously jeopardize U.S. influence in the potentially huge future multimedia market. This fear has prompted computer firms to strengthen ties with Japanese firms and expand product lines to include consumer electronics. In January 1992, Apple Computer announced plans to roll out three new product lines in the next two years, focusing on the consumer electronics market, including video games, electronic organizers, and cellular phones. Realizing that it cannot forge this leap to home electronics alone, Apple has strengthened it ties with Sony. Microsoft has promised to use a similar strategy to ensure its stake in the future of multimedia. (Zachary, January 10, 1992, p. B2)

Another rising market that will receive more attention in the 1990s is the computer services market. In an industry where commodity pricing on the bulk of products is now the norm, more manufacturers are turning to the computer service

sector and its double digit profit margins (Verity, January 13, 1992, p. 97).

Most recently, two service sectors have become major bright spots in the computer services arena: building networks and outsourcing. In an era when computing equals networking, many companies are providing customers help in designing and building networks. This market niche puts computing power back in the hands of computer professionals, who were dethroned during the PC revolution. Combined with outsourcing, these two service sectors are expected to grow in 1992 by 20% or more, to about $18.8 billion in combined revenues. (Verity, January 13, 1992, p. 97)

The concept of outsourcing is even more promising than building networks. Outsourcing involves "taking responsibility for all of a customer's data processing activities under a fixed-fee contract." (Verity, January 13, 1992, p. 97) With the current shrinking data processing budgets, more companies are finding that outsourcing can save big bucks, especially companies that use information technology (IT) in a support role. In a startling 1989 move, Kodak sold its mainframes to IBM and hired the IBM to do its data processing for the next ten years (Kirkpatrick, September 23, 1991, 103). Kodak's director of information justified the move explaining,

> IBM is in the data processing business, and Kodak isn't. IBM runs our computer center as it's supposed to be run -

as a profit center rather than a cost center. (Kirkpatrick, September 23, 1991, p. 103)

Other major companies following Kodak's lead in outsourcing include National Car Rental System, Cummins Engine, the Matson Navigation shipping line, Enron, and Signet Banking of Richmond (Kirkpatrick, September 23, 1991, p. 103). Information systems consultants today predict "that about half the major U.S. corporations they work with have launched or plan to launch a formal analysis of whether outsourcing makes sense for them." (Kirkpatrick, September 23, 1991, p. 103) According to Input, a California-based computer market research firm, U.S. businesses will spend $15.2 billion on outsourcing by 1995, more than double the $7.2 billion spent in 1990 (Kirkpatrick, September 23, 1991, p. 103).

Expected savings from outsourcing promise to be substantial. Enron, a natural gas producer, "expects to save $200 million in this decade - 20% to 24% of total computing costs." (Kirkpatrick, September 23, 1991, p. 104) Kodak has already realized a combined annual savings of around 40%, which could equate to as much as $130 million over ten years (Kirkpatrick, September 23, 1991, p. 104).

These promised savings will entice a host of other corporations to join this rising trend, especially those that do not view information technology as a strategic part of their business. By the end of the decade outsourcing could include as much as 40% of corporate America.

Given the market potential for outsourcing and the generous gross profit margins of the business - often 25% to 30%, the computer industry of the future will see more computer firms invade this sector. In 1990, Electronic Data Systems (EDS), a subsidiary of General Motors, had the hold on the outsourcing market with nearly 21% of the world market share and nearly half of all major long-term outsourcing contracts. IBM was second, with a world market share of about 13%, followed by the five other major competitors, each holding single-digit world market shares. (Kirkpatrick, September 23, 1991, p. 104) In the future, more hardware companies are expected to tap this profit-making sector. In an era when software defines computing, the industry will see software companies infiltrate this sector as well.

Ultimately, outsourcing may help move U.S. firms further towards a new form of corporate interdependence, extending computer firms' ties beyond the boundaries of the computer industry to form a U.S. version of Japan's keiretsu. According to Michael Teracy, a Cambridge management consultant, outsourcing could serve as a part of America's answer to keiretsu. (Kirkpatrick, September 23, 1991, p. 112)

G. Changing Selling Channels

The evolution of computers, from the custom-built luxuries of past decades to the commodities of today, has changed the way manufacturers sell computers today and will continue to

affect sales strategies of the future. This portion of the study will view the evolution of the industry's sales strategies and forecast the strategies that will succeed in the future computer industry.

1. Sales Strategies of Past Decades

Computer sales prior to the PC revolution were characterized by direct individual sales, mainly because computers were custom-built, personalized systems. These exchanges usually involved white-collar workers on both sides of the table. The transactions of these "elite" parties involved not only the sale of the computer, but a commitment to a long-standing relationship between the two parties.

As the PC revolution hit in the early and mid 1980s, hoards of small entrepreneurs sought to sell their products in retail stores. At the end of 1983, retail stores and manufacturer-owned product centers in the U.S. numbered almost 4000, the largest being franchises such as Computerland, Businessland, and Egghead (McClellan, 1988, p. 212).

While the initial idea of a central location for computer products was appealing, these franchises encountered a number of problems. An immediate problem by the mid 1980s was trying to accommodate the hundreds of clones with limited shelf space and limited "mind space." For instance, a Computerland store would push the products of five different vendors at best (McClellan, 1988, p. 212). Another problem

was that consumers did not want to pay the commissions of the sales personnel in addition to the price of the product. Computer franchises attempted to sell computers using a strategy similar to car dealerships.

Perhaps the most significant problem with retail sales was that local retail stores offered no real value to the customer. People who understood the technology quickly rose above the low levels of support services, leaving retail stores with unqualified support personnel offering poor support.

Another downfall in retail store support was the concept of "full service dealers," a policy mandating that customers go through the dealer for all computer services. This concept never really materialized because customers found the so called "full service" to be a paper drill. In practice, customers found that dealers had very few items in stock and had lengthy turnaround times on equipment. Customers soon found that it was cheaper and faster to go directly to the manufacturer for service.

2. Strategies of the Late 1980s and 1990s

Faced with the problems of retail sales, computer manufacturers, such as Dell Computer, began offering mail-order sales through catalogs in the late 1980s. They dismissed the concept of full service dealers. This direct sales strategy offered marked advantages over previous

strategies. Most importantly, the concept allowed companies to offer great prices, in an era when price and performance were becoming the only real distinguishing factors in computer hardware. The new global delivery systems of mail-order firms also delivered products within hours of the order. Direct sales also allowed firms to offer superior 24 hour support, due to the low overhead of this sales strategy.

Dell Computer's success demonstrated how consumers viewed the advantages of direct sales. Dell built a $546 million business selling Pcs through the mail. In the industry as a whole, "Research Workgroup Technologies Inc. says 24% of computers sold in 1991 moved through the mail." (Eng, November 25, 1991, p. 232C) Analysts predict that by 1995 the figure will be 30%. The advantages and low overhead that direct sales offer have even the biggest computer companies getting set "to ride the mail-order wave." (Eng, November 25, 1991, p. 232C) In revolutionary moves from past sales strategies, Compaq Computer Corporation and IBM have announced plans to set up mail-order distribution for PCs. (Eng, November 25, 1991, p. 232C) In the future, expect to see other computer manufacturers join this mail-order wave, a trend that fits the computer commodities of the 1990s.

H. Market Forecasts

The changing values, markets and strategies in the computer industry, combined with the forces of innovation,

government and industry actions, will reshape the markets of the future and redistribute power among those markets. This portion of the study provides a look at these future markets and forecasts the leaders in each market, those firms with the power and forethought to exploit the changes in the 1990s.

1. High-End Computers

By the end of the decade, the supercomputer market will probably be the only viable high-end market segment. The prevailing trends of miniaturization, increasing computing power per dollar, and proliferation of networks will shrink the mainframe and minicomputer market segments by as much as 30% in the 1990s. Companies currently in the mainframe and minicomputer manufacturing business will eventually shift manufacturing strategies towards either the high or low end poles in computing, or both. Given these shifts, the companies that succeed in the high-end market will be those that master and exploit upcoming technologies in the supercomputer market, such as massively parallel processing. The following list outlines the companies that will prosper in this segment.

- IBM - IBM's deep pockets, extensive mainframe experience and recent ties with Thinking Machines will put them in a relatively good position to exploit the supercomputer market.

- NCR - NCR's support from AT&T, combined with its recent technology infusion from Teradata, will set the stage for future success in the supercomputer market.

The supercomputer market can also expect strong competition from Japanese industry giants such as Fujitsu, Hitachi and NEC.

In the shrinking mainframe and minicomputer market segments, U.S. firms will grudgingly lose their footholds to the more efficient Japanese manufacturing firms. By the end of the decade, Japanese firms such as Fujitsu, Hitachi, NEC, and Toshiba will dominate these two markets as both U.S. and Japanese computer firms exploit their strengths rather than their weaknesses. U.S. firms will shift the focus to machines that are influenced more by software, the U.S. strength. Japanese firms will continue to focus on its strength in efficient hardware manufacturing.

2. Desktop Systems

The desktop market of the future will fill the void left by the shrinking mainframe and minicomputer markets. Dataquest predicts that desktop sales will grow 25% in 1992, due to increased performance for price and a big industry move to client-server networks. New operating systems in workstations and PCs of the future will continue to blur the lines between the two types of machines. By the end of the decade, the merge will probably be complete, making PCs and workstations virtually indistinguishable. The future leaders in desktop manufacturing will be the firms that win the war in establishing the operating systems that define how these

machines will be used. Thus, leaders in the future desktop market will be tied heavily to, if not the leaders in, the software market. Given the future merger of market segments, the following firms will hold the desktop market power of the future.

- IBM/Apple - The combination of these two PC leaders will be hard to beat. IBM's deep pockets and forethought, combined with Apple's technical superiority will fuse to make an entity that even Microsoft will fear.
- Microsoft/DEC - This relatively quiet combination will mesh DEC's manufacturing skills with the momentum of Microsoft's Windows program to exploit the desktop market.
- Sun - The company that mastered leveraging its advantages in the workstation market will apply that same expertise to prosper in the desktop market of the 1990s.
- NeXT - Though probably a long shot, Jobs provides NeXT with the forethought and focus on the technologies that will ensure success.

3. Software

In the past decade, software became the distinguishing factor among computers because it defined how the machines were used. As a result, the industry exploded from just over $10 billion in 1984 to over $33 billion in 1990, in constant 1990 dollar revenues. The software industry will continue to experience this type of growth as it tackles the technologies of the future. The hardware innovations of tomorrow, such as pen computers, multimedia, and client server networks are software challenges more than hardware challenges. Due to this increased reliance on software, software companies of the

future will wield even more power in the computer industry as a whole, especially in the low-end markets. Microsoft's power today exemplifies this trend. The future leaders in this industry will parallel those of the desktop market, as the two markets become more intertwined. The firms that tap and exploit promising software technologies of tomorrow, such as the advantages of object oriented programming (OOP), will also wield substantial power in the future software market. Given this environment the following firms will probably lead the software industry of the future.

- Microsoft - Microsoft's current power in the industry gives the company an overwhelming advantage in the future software market. Gates forethought and exploitation expertise will always keep Microsoft in the top three.

- IBM/Apple - This tandem's focus on OOP could prove to bring Microsoft down a notch or two in the 1990s. If not, expect IBM to increase its ties with other companies touting OOP, such as NeXT. IBM could also encourage, rather than discourage Apple's ties with Sony in the future, to better exploit the multimedia market.

- NeXT - Job's forethought and focus on OOP will make NeXt a competitor in the software industry as well as the desktop market.

- Computer Associates - This company's recent acquisition strategy is building power. Its lack of ties throughout the industry, however, may be a disadvantage in the future.

4. Other Rising Market Segments

The other major market segments in the 1990s, excluding peripherals, will be what this study calls the mini PC segment, consisting of laptops, notebooks, and pen computers and the computer services market.

The mini PC sector will experience the growth that the PC market saw in the 1980s, growing by as much as 30%. Japan's current lead in the mini PC sector will diminish throughout the 1990s, as software problems overtake manufacturing problems. Toshiba, Fujitsu, and NEC will wield substantial power in the laptop market during the next few years. Among U.S. strengths in latops will include Hewlett-Packard, Texas Instruments, and IBM-Apple. As software challenges in the mini PC market increase, expect to see some software firms, such as Microsoft, dabble in this segment.

Developments in the pen computer segment, touted as having the same potential as the PC in the 1980s, are probably hardest to predict. Among those that introduced new products at the Comdex show in Las Vegas are AT&T's NCR Corporation, Tandy, Samsung Electronics, and ever-present NEC. The major problems in this market again will be software problems, as companies attempt to develop proprietary systems to better handle handwriting complexities. Given this software problem, expect software giants, like Microsoft and IBM-Apple, to try to set and exploit new standards in this promising market.

The computer services market has a bright future. Industry leaders in this market however, unlike other markets in the industry, are more stable due to the length of contracts. As software problems become increasingly more prevalent in the 1990s, this sector will see a push from previously uninterested software companies.

TABLE 1: THE 1957 COMPUTER INDUSTRY
TOP FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	78.5
2	Sperry Rand	16.3
3	Burroughs	3.9
4	RCA	0.8
5	Honeywell	0.3
6	NCR	0.06

SOURCE: (Brock, 1975, p. 22)

TABLE 2: THE 1958 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	77.4
2	Sperry Rand	16.3
3	Burroughs	3.3
4	RCA	1.8
5	Honeywell	1
6	General Electric	0.2
7	NCR	0.04

SOURCE: (Brock, 1975, p. 22)

TABLE 3: THE 1959 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	74.5
2	Sperry Rand	17.8
3	Burroughs	4.2
4	RCA	1.4
5	Honeywell	1.2
6	General Electric	0.9
7	NCR	0.12

SOURCE: (Brock, 1975, p. 22)

TABLE 4: THE 1960 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	71.6
2	Sperry Rand	16.2
3	Burroughs	3.4
4	General Electric	2.8
5	RCA	2.4
6	Control Data	1
7	Honeywell	0.9
8	NCR	0.4

SOURCE: (Brock, 1975, p. 22)

TABLE 5: THE 1961 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	69.3
2	Sperry Rand	15.5
3	General Electric	3.4
4	RCA	3
5	Burroughs	2.6
6	Control Data	2.2
7	Honeywell	2
8	NCR	0.7

SOURCE: (Brock, 1975, p. 22)

TABLE 6: THE 1962 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	70
2	Sperry Rand	12.4
3	General Electric	3.7
4	RCA	3.5
5	Control Data	3.1
6	Honeywell	2.3
7	Burroughs	2.2
8	NCR	1.9

SOURCE: (Brock, 1975, p. 22)

TABLE 7: THE 1963 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	69.3
2	Sperry Rand	11.2
3	Control Data	4
4	General Electric	3.5
5	RCA	3.5
6	NCR	2.7
7	Burroughs	2.6
8	Honeywell	1.8

SOURCE: (Brock, 1975, p. 22)

TABLE 8: THE 1964 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	68.3
2	Sperry Rand	11.8
3	Control Data	4.4
4	General Electric	3.3
5	Burroughs	3.1
6	RCA	3
7	NCR	2.8
8	Honeywell	2.7

SOURCE: (Brock, 1975, p. 22)

TABLE 9: THE 1965 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	65.3
2	Sperry Rand	12.1
3	Control Data	5.4
4	Honeywell	3.8
5	Burroughs	3.5
6	General Electric	3.4
7	NCR	2.9
8	RCA	2.9

SOURCE: (Brock, 1975, p. 22)

TABLE 10: THE 1966 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	66.2
2	Sperry Rand	11.3
3	Control Data	5.3
4	Honeywell	5.2
5	General Electric	3.5
6	Burroughs	3
7	RCA	2.7
8	NCR	2.4

SOURCE: (Brock, 1975, p. 22)

TABLE 11: THE 1967 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	68.1
2	Sperry Rand	10.6
3	Control Data	4.7
4	Honeywell	4.7
5	RCA	3.2
6	General Electric	3
7	Burroughs	2.9
8	NCR	2.5

SOURCE: (Brock, 1975, p. 22)

TABLE 12: THE 1968 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	73.8
2	Sperry Rand	5.6
3	Honeywell	4.1
4	Control Data	2.9
5	General Electric	3.2
6	RCA	2.4
7	NCR	2.2
8	Burroughs	2.1

SOURCE: (Brock, 1975, p. 22)

TABLE 13: THE 1970 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	70.6
2	Control Data	7.3
3	Honeywell	4.8
4	Burroughs	3.4
5	Sperry Rand	3.2
6	General Electric	3.1
7	NCR	2.3
8	RCA	2.1

SOURCE: (Brock, 1975, p. 22)

TABLE 14: THE 1971 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	67.4
2	Control Data	7.7
3	Honeywell	7.6
4	Sperry Rand	4.4
5	Burroughs	4.1
6	NCR	2.5
7	RCA	2.1

SOURCE: (Brock, 1975, p. 22)

TABLE 15: THE 1973 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	45.4
2	Honeywell	6.2
3	Burroughs	5.9
4	Sperry Rand	5.1
5	Control Data	5
6	NCR	4.3
7	DEC	1.4
8	TRW	1.2
9	Memorex	0.9
10	Hewlett-Packard	0.9

NOTE: Estimates for market share percentages were calculated based on the total revenues for each firm for 1973 and the 1975 estimated DP percentage of total revenues.

SOURCE: (Rothenbuecher, June 1976, pp. 48-59)

TABLE 16: THE 1974 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	47.1
2	Burroughs	6.3
3	Honeywell	6.1
4	Sperry Rand	5.4
5	Control Data	5.2
6	NCR	4.2
7	DEC	2
8	TRW	1.2
9	Hewlett-Packard	1.1
10	Memorex	1.1

NOTE: Estimates for market share percentages were calculated based on the total revenues for each firm for 1974 and the 1975 estimated DP percentage of total revenues.

SOURCE: (Rothenbuecher, June 1976, pp. 48-59)

TABLE 17: THE 1975 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	47.6
2	Burroughs	6.2
3	Honeywell	5.7
4	Sperry Rand	5.5
5	Control Data	5.2
6	NCR	4.1
7	DEC	2.3
8	Memorex	1.1
9	Hewlett-Packard	1.1
10	TRW	1.1

NOTE: Market shares were calculated from the DP revenues of each firm and the combined revenues of the top 50 firms in the industry, esitmated to be 95% of the total industry revenues.

SOURCE: (Rothenbuecher, June 1976, pp. 48-59)

TABLE 18: THE 1976 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	47.8
2	Burroughs	6.1
3	Sperry Rand	5.4
4	Honeywell	5.4
5	Control Data	5
6	NCR	4.1
7	DEC	2.8
8	Hewlett-Packard	1.3
9	Memorex	1.2
10	TRW	1.1

NOTE: Market shares were calculated from the DP revenues of each firm and the combined revenues of the top 50 firms in the industry, esitmated to be 95% of the total industry revenues.

SOURCE: (Rothenbuecher, June 1977, pp. 61-74)

TABLE 19: THE 1977 COMPUTER INDUSTRY

TOP TEN FIRMS

BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	47.4
2	Burroughs	5.9
3	NCR	5.1
4	Control Data	4.9
5	Sperry Rand	4.7
6	DEC	3.4
7	Honeywell	3.3
8	Memorex	1.3
9	Hewlett-Packard	1.3
10	TRW	1.1

NOTE: Market shares were calculated from the DP revenues of each firm and the combined revenues of the top 50 firms in the industry, esltmated to be 95% of the total industry revenues.

SOURCE: (Rothenbuecher, June 1978, pp. 85-110)

TABLE 20: THE 1978 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	44.9
2	Burroughs	5.5
3	NCR	5.1
4	Control Data	4.9
5	Sperry Rand	4.8
6	DEC	3.8
7	Honeywell	3.4
8	Hewlett-Packard	1.7
9	Memorex	1.5
10	Itel	1.3

NOTE: Market shares were calculated from the DP revenues of each firm and the combined revenues of the top 50 firms in the industry, esitmated to be 95% of the industry revenues. DP revenues for this year (1978) were measured from bar graphs using a graduated scale.

SOURCE: (Barna, May 25, 1979, pp. 15-75)

TABLE 21: THE 1979 COMPUTER INDUSTRY
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	40.2
2	Burroughs	5.3
3	NCR	5.3
4	Control Data	5
5	Sperry Rand	5
6	DEC	4.5
7	Honeywell	3.2
8	Hewlett-Packard	2.3
9	Memorex	1.5
10	Data General	1.2

NOTE: Market shares were calculated from the revenues of each firm and the combined revenues of the top 50 firms in the industry, esitmated to be 95% of the total industry revenues.

SOURCE: (Gartner Group, July 1980, pp. 87-182)

TABLE 22: INDUSTRY MARKETS

(billions)

YEAR	MAINFRAMES	MINIS	MICROS	TOTAL IS REVENUE
1979	13.3	6.9	.42	46
1980	15.1	8.8	.77	55.6
1981	17.6	9.5	2.7	67.8
1982	18.7	10.3	3.6	79.4
1983	18.3	15.5	7.7	92
1984	23.2	13.8	11.7	132
1985	25.3	16.8	15.3	150.8
1986	28.1	17.1	19.3	177
1987	26.9	21.7	23.6	208.9
1988	30.3	24.1	28.4	243.1
1989	28.2	23	37.4	255.8
1990	21.7	22.3	39	278.5

SOURCE: Datamation's annual Datamation 100, from 1980 to 1991.

TABLE 23: INDUSTRY MARKETS IN 1990 DOLLARS

(billions)

YEAR	MAINFRAMES	MINIS	MICROS
1979	23.9	12.4	.75
1980	24	14	1.2
1981	25.3	13.7	3.9
1982	25.2	13.9	4.9
1983	24	15.5	10.1
1984	29.2	18.1	14.7
1985	30.6	20.3	18.5
1986	33.4	20.3	23
1987	30.9	25	27.1
1988	33.6	26.8	31.5
1989	29.6	24.2	39.3
1990	21.7	22.3	39

SOURCE: Calculated from the values in Table 22 using the Consumer Price Index.

TABLE 24: 1980 MAINFRAME MARKET SHARES

TOP TEN FIRMS

BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	72.7
2	Honeywell	7
3	Burroughs	6.7
4	NCR	6
5	Sperry Rand	5.6
6	Control Data	3.7

SOURCE: (Wright, June 1981, pp. 91-192)

TABLE 25: 1981 MAINFRAME MARKET SHARES

TOP TEN FIRMS

BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	68.1
2	Burroughs	7.1
3	Honeywell	6.3
4	Sperry Rand	5.2
5	NCR	5.2
6	Control Data	3.5

SOURCE: (Archbold, June 1982, pp. 114-226)

TABLE 26: 1982 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	70
2	Sperry Rand	8.6
3	Burroughs	8.3
4	NCR	4.4
5	Control Data	3.4
6	Honeywell	2.7
7	Amdahl	1.5
8	National Semicond.	0.8
9	Cray	0.6

SOURCE: (Archbold, June 1983, pp. 86-202)

TABLE 27: 1983 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	62.7
2	Burroughs	10.9
3	Honeywell	5.6
4	NCR	5.5
5	Control Data	4.2
6	Sperry Rand	3.8
7	Amdahl	3.1
8	National Semicond.	1.1
9	Cray	0.9

SOURCE: (Archbold, June 1, 1984, pp. 52-144)

TABLE 28: 1984 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	56.5
2	Sperry Rand	6.2
3	Burroughs	6.2
4	Fujitsu	6
5	NCR	5.8
6	NEC	3.9
7	Control Data	3.5
8	Siemens	3.5
9	Hitachi	3.3
10	Honeywell	2.9

SOURCE: (Verity, June 1, 1985, pp. 36-100)

TABLE 29: 1985 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	55.4
2	Sperry Rand	7.5
3	Fujitsu	6.4
4	NEC	4.8
5	Control Data	3.4
6	Hitachi	3.3
7	Honeywell	3.1
8	Burroughs	2.9
9	Groupe Bull	2.3
10	NCR	1.9

SOURCE: (Archbold, June 15, 1986, pp. 42-158)

TABLE 30: 1986 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	51.4
2	Fujitsu	8.8
3	NEC	8.1
4	Unisys	7.8
5	Hitachi	4.9
6	Groupe Bull	2.9
7	Honeywell	2.6
8	Siemens	2.1
9	Cray	1.9
10	Amdahl	1.8

SOURCE: (Datamation Staff, June 15, 1987, pp. 28-28)

TABLE 31: 1987 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	41.6
2	Fujitsu	12.3
3	NEC	11.5
4	Hitachi	6.9
5	Unisys	5.3
6	Groupe Bull	3.6
7	Amdahl	3.4
8	Siemens	2.6
9	STC	2.2
10	Cray	2.2

SOURCE: (Runyan, June 15, 1988, pp. 155-166)

TABLE 32: 1988 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	40.1
2	Fujitsu	13.8
3	NEC	13.3
4	Hitachi	8.3
5	Amdahl	4
6	Unisys	3.9
7	Groupe Bull	3
8	Siemens	2.3
9	Cray	2.1
10	Control Data	1.5

SOURCE: (Milunovich, June 15, 1989, p. 150)

TABLE 33: 1989 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	44.4
2	Fujitsu	11.6
3	Hitachi	11.1
4	NEC	8.5
5	Amdahl	5.2
6	Unisys	4.3
7	Groupe Bull	3
8	Cray	2.2
9	Siemens	2.2
10	STC	1.7

SOURCE: (Payne, June 15, 1990, pp. 188-189)

TABLE 34: 1990 MAINFRAME MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	49
2	Fujitsu	17
3	Hitachi	15.8
4	NEC	13
5	Amdahl	6.3
6	Nixdorf	4.7
7	Unisys	4.7
8	Groupe Bull	3.8
9	Cray	2.7
10	Control Data	1.2

NOTE: Calculated from revenues in Datamation's Top North American frims, European firms, and Asian firms.

SOURCE: (Kelly, June 15, 1991, pp. 22-33)
(Appelton, July 1, 1991, pp. 60-64)
(Johnston, September 1, 1991, pp. 62-81)

TABLE 35: 1980 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	19.6
2	Data Control	5.7
3	Hewlett-Packard	4.2
4	Honeywell	2.8
5	Prime	2.7
6	Management Asst.	2.2
7	Wang	1.7
8	Nixdorf	1.6
9	Tandem	1.3
10	McDonnel-Douglas	1.1

SOURCE: (Wright, June 1981, pp. 91-192)

TABLE 36: 1981 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	21
2	Data General	5.8
3	Hewlett-Packard	4.4
4	Prime	3.1
5	Honeywell	3
6	Wang	2.8
7	Management Asst.	2.3
8	Tandem	2.2
9	Nixdorf	1.6
10	McDonnel-Douglas	1.5

SOURCE: (Archbold, June 1982, pp. 114-226)

TABLE 37: 1982 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	29.1
2	DEC	16.3
3	Burroughs	7.8
4	Data General	5.8
5	Hewlett-Packard	5.7
6	Wang	5.7
7	Prime	3.4
8	Honeywell	3.2
9	Gould	3.1
10	Texas Instruments	2.9

SOURCE: (Archbold, June 1983, pp. 86-202)

TABLE 38: 1983 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	DEC	17.3
2	IBM	16.8
3	Burroughs	6.1
4	Wang	5.7
5	Hewlett-Packard	4.7
6	Data General	4.5
7	Prime	2.7
8	Tandem	2.6
9	Gould	2.1
10	Honeywell	2.1

SOURCE: (Archbold, June 1, 1984, pp. 52-144)

TABLE 39: 1984 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	21.8
2	DEC	11.1
3	Wang	7
4	Hewlett-Packard	6.9
5	Data General	6.1
6	Burroughs	5.1
7	Olivetti	3.9
8	Prime	3.5
9	Tandem	3.5
10	Toshiba	3.1

SOURCE: (Verity, June 1, 1985, pp. 36-100)

TABLE 40: 1985 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	20.8
2	DEC	9.5
3	Hewlett-Packard	6.3
4	Wang	5.2
5	Data General	4.8
6	Prime	3.4
7	Tandem	3.2
8	Harris	2.8
9	Fujitsu	2.6
10	Nixdorf	2.4

SOURCE: (Archbold, June 15, 1986, pp. 42-158)

TABLE 41: 1986 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	17.5
2	DEC	11.7
3	Hewlett-Packard	6.4
4	Wang	4.7
5	Toshiba	4.5
6	Fujitsu	3.6
7	Unisys	3.5
8	Olivetti	2.9
9	Mitsubishi	2.8
10	Data General	2.6

SOURCE: (Datamation Staff, June 15, 1987, pp. 28-38)

TABLE 42: 1987 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	19.9
2	DEC	15
3	Hewlett-Packard	5.6
4	Toshiba	4.2
5	Wang	4.2
6	Fujitsu	3.7
7	Mitsubishi	3
8	Olivetti	2.8
9	Nixdorf	2.6
10	NCR	2.2

SOURCE: (Runyan, June 15, 1988, pp. 155-166)

TABLE 43: 1988 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	18.2
2	DEC	15.5
3	Hewlett-Packard	6.2
4	Sun Microsystems	4.5
5	Toshiba	4.5
6	Unisys	4.5
7	Fujitsu	4.1
8	Wang	3.8
9	Nihon Unisys	2.7
10	Prime	2.6

SOURCE: (Smith, June 15, 1989, p. 152)

TABLE 44: 1989 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	29.4
2	DEC	11.6
3	NEC	6.4
4	Fujitsu	5.7
5	Unisys	4.9
6	Toshiba	4.3
7	Hewlett-Packard	3.3
8	Tandem	3.1
9	Olivetti	2.6
10	Wang	2.5

SOURCE: (Johnson, June 15, 1990, pp. 186-187)

TABLE 45: 1990 MINI MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	26
2	DEC	12.7
3	NEC	7.8
4	Fujitsu	6.4
5	Toshiba	5
6	Unisys	4.9
7	Nixdorf	4.1
8	Tandem	3.5
9	Hewlett-Packard	3.3
10	Prime	2.5

NOTE: Calculated from revenues in Datamation's North America 100, European, and Asian top firms.

SOURCE: (Kelly, June 15, 1991, pp. 22-23)
(Appelton, July 1, 1991, pp. 60-64
(Johnston, September 1, 1991, pp. 62-81)

TABLE 46: 1980 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	Hewlett-Packard	25.7
2	Apple	21.2
3	Tandy	19.2
4	Commodore	13.4
5	Gould	12.8
6	Cado	7.2
7	Cromemco	5.8
8	M/A-Com	2.6

SOURCE: (Wright, June 1981, pp. 91-192)

TABLE 47: 1981 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	Apple	14.8
2	Tandy	10.8
3	Hewlett-Packard	8.7
4	Commodore	5.2
5	Gould	5.2
6	Cado	2.5
7	Cromemco	2.2
8	M/A-Com	0.9

SOURCE: (Archbold, June 1982, pp. 114-226)

TABLE 48: 1982 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	Apple	18.6
2	IBM	14
3	Tandy	13
4	Commodore	10.3
5	Hewlett-Packard	6.6
6	Texas Instruments	6.5
7	DEC	5.6

SOURCE: (Archbold, June 1983, pp. 86-202)

TABLE 49: 1983 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	33.8
2	Apple	14.1
3	Commodore	12
4	Tandy	7.8
5	Hewlett-Packard	5.2
6	DEC	3.9
7	Texas Instruments	2
8	Compaq	1.4
9	Wang	1.3
10	NCR	1.1

SOURCE: (Archbold, June 1, 1984, pp. 52-144)

TABLE 50: 1984 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	34.2
2	Apple	16.2
3	Commodore	9.6
4	Hewlett-Packard	4.4
5	Sperry Rand	4.3
6	Tandy	3.4
7	Convergent	3.1
8	Compaq	2.8
9	Olivetti	2.5
10	NEC	2.2

SOURCE: (Verity, June 1, 1985, pp. 36-100)

TABLE 51: 1985 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	35.9
2	Apple	10.5
3	Olivetti	5.8
4	Tandy	5.2
5	Sperry	4.9
6	Commodore	3.9
7	Compaq	3.3
8	Hewlett-Packard	2.6
9	Convergent	2.6
10	Zenith	2.3

SOURCE: (Archbold, June 15, 1986, pp. 42-158)

TABLE 52: 1986 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	15.5
2	Apple	9.2
3	Olivetti	6.6
4	Tandy	5.2
5	Unisys	4.1
6	NEC	3.6
7	Compaq	3.2
8	AT&T	3.1
9	Toshiba	3
10	Zenith	2.8

SOURCE: (Datamation Staff, June 15, 1987, pp. 28-38)

TABLE 53: 1987 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	29.6
2	Apple	8.7
3	Compaq	5.2
4	Olivetti	5
5	Tandy	4.8
6	Unisys	4.5
7	Zenith	4.4
8	NEC	4
9	Toshiba	3.4
10	AT&T	2.3

SOURCE: (Runyan, June 15, 1988, pp. 155-166)

TABLE 54: 1988 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	25.5
2	Apple	10.5
3	Compaq	7.4
4	Olivetti	5.1
5	Tandy	4.4
6	Zenith	4.4
7	NEC	4.3
8	Toshiba	3.9
9	Unisys	3.7
10	Amstrad	2.8

SOURCE: (Ewell, June 15, 1989, p. 154)

TABLE 55: 1989 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	22.3
2	Apple	9.6
3	NEC	8.3
4	Compaq	7.7
5	Groupe Bull	4.5
6	Olivetti	4.1
7	Toshiba	3.6
8	Tandy	3.6
9	Unisys	3.5
10	Fujitsu	2.3

SOURCE: (Dunkle, June 15, 1990, pp. 184-185)

TABLE 56: 1990 MICRO MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	24.7
2	Apple	9.9
3	NEC	9.3
4	Compaq	9.2
5	Toshiba	6.4
6	Olivetti	4.6
7	Fujitsu	3.6
8	Unisys	3
9	Commodore	2.6
10	Intel	2.5

NOTE: Calculated from revenues in the Datamation's top 1991 rankings in North America, Europe and Asia.

SOURCE: (Kelly, June 15, 1991, pp. 22-33)
(Appelton, July 1, 1991, pp. 60-64)
(Johnston, September 1, 1991, pp. 62-81)

TABLE 57: SOFTWARE & SERVICES, 1975-1983

(billions)

YEAR	SOFTWARE & SERVICES REVENUES	TOTAL IS REVENUES	PERCENTAGE
1975	4.1	23.4	17.5
1976	4.7	26.6	17.7
1977	5.4	31.2	17.3
1978	8.1	38	21.3
1979	11.8	45.6	25.9
1980	17.1	55.6	30.8
1981	16.4	67.8	24.2
1982	17.7	79.4	22.3
1983	11.2	92	12.2

SOURCE: Calculated from revenues and software and service percentages in the annual Datamation 100

TABLE 58: SOFTWARE & SVCS IN 1990 DOLLARS

(billions)

YEAR	SOFTWARE & SERVICES REVENUES
1975	10
1976	10.8
1977	11.7
1978	16.2
1979	21.2
1980	27.2
1981	23.6
1982	23.9
1983	14.7

SOURCE: Calculated from the values in Table 57 using the Consumer Price Index

TABLE 59: 1975 SOFTWARE & SVCS MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	26.9
2	Control Data	10.6
3	Burroughs	7
4	Sperry Rand	6.3
5	NCR	5.1
6	Computer Sciences	4.3
7	TRW	4.2
8	McDonnel-Douglas	3.9
9	General Electric	3.6
10	Itel	3.6

SOURCE: (Rothenbuecher, June 1976, pp. 48-59)

TABLE 60: 1976 SOFTWARE & SVCS MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	35
2	Control Data	10.1
3	Burroughs	8.3
4	Sperry Rand	7.6
5	NCR	5.6
6	TRW	5
7	Itel	4
8	Automatic Data	3.8
9	Computer Sciences	3.5
10	General Electric	3.4

SOURCE: (Rothenbuecher, June 1977, pp. 61-74)

TABLE 61: 1977 SOFTWARE & SVCS MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	24.5
2	Control Data	11.2
3	Burroughs	8.2
4	NCR	7.9
5	Sperry Rand	4.9
6	TRW	4.5
7	Automatic Data	4.4
8	DEC	3.9
9	Computer Sciences	3.3
10	Electronic Data	2.9

SOURCE: (Rothenbuecher, June 1978, pp. 85-110)

TABLE 62: 1978 SOFTWARE & SVCS MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	21
2	Control Data	9.5
3	Burroughs	9.1
4	NCR	8.4
5	DEC	5.1
6	Sperry Rand	4.6
7	TRW	4.4
8	Automatic Data	4
9	Computer Sciences	3.6
10	Itel	2.2

SOURCE: (Barna, May 25, 1979, pp. 15-75)

TABLE 63: 1979 SOFTWARE & SVCS MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	27.9
2	Control Data	8.1
3	NCR	5.7
4	Burroughs	5.6
5	Sperry Rand	4.6
6	DEC	4.1
7	Computer Sciences	3.5
8	Automatic Data	3.4
9	General Electric	3
10	Honeywell	2.9

SOURCE: (Gartner Group, July 1980, pp. 87-182)

TABLE 64: 1980 SOFTWARE & SVCS MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	35
2	Control Data	6
3	NCR	6
4	Burroughs	5.1
5	Honeywell	4.4
6	DEC	4
7	Sperry	4
8	Computer Sciences	3.3
9	Automatic Data	3
10	Electronic Data	2.4

SOURCE: (Wright, June 1981, pp. 91-192)

TABLE 65: 1981 SOFTWARE & SVCS MARKET SHARES

TOP TEN FIRMS

BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	27.3
2	Control Data	7
3	NCR	6.3
4	DEC	5.6
5	Burroughs	5.1
6	Honeywell	5.1
7	TRW	4.4
8	Sperry	4.2
9	Computer Sciences	3.8
10	Automatic Data	3.7

SOURCE: (Archbold, June 1982, pp. 114-226)

TABLE 66: 1982 SOFTWARE & SVCS MARKET SHARES

TOP TEN FIRMS

BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	30
2	Burroughs	7.1
3	DEC	7
4	Control Data	6.5
5	NCR	6.2
6	Sperry	4.5
7	Hewlett-Packard	4
8	Automatic Data	4
9	Computer Sciences	3.9
10	TRW	3.8

SOURCE: (Archbold, June 1983, pp. 86-202)

TABLE 68: SOFTWARE, 1984-1990

(billions)

YEAR	SOFTWARE DEVELOPMENT REVENUES	TOTAL IS REVENUES	PERCENTAGE
1984	8.2	132	6.2
1985	11.5	150.8	7.6
1986	13.3	177	7.5
1987	17	208.9	8.1
1988	20.8	243.1	8.6
1989	24.6	255.8	9.6
1990	33.1	278.5	11.9

SOURCE: Calculated from revenues and software segment percentages in the annual Datamation 100

TABLE 69: SOFTWARE INDUSTRY IN 1990 DOLLARS

1984-1990
(billions)

YEAR	SOFTWARE DEVELOPMENT REVENUES
1984	10.3
1985	13.9
1986	15.8
1987	19.6
1988	23.1
1989	25.8
1990	33.1

SOURCE: Calculated from the values in Table 68 using the Consumer Price Index.

TABLE 70: 1984 SOFTWARE MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	39
2	TRW	10.1
3	NCR	7.3
4	Hewlett-Packard	6.1
5	NEC	3.7
6	Sperry	2.5
7	Burroughs	2.4
8	DEC	2.4
9	Fujitsu	2.4
10	Nixdorf	2

SOURCE: (Verity, June 1, 1985, pp. 36-100)

TABLE 71: 1985 SOFTWARE MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	36.2
2	TRW	9.6
3	Burroughs	6.2
4	Hewlett-Packard	4.3
5	NCR	3.5
6	NEC	3.3
7	DEC	2.6
8	Sperry	2.5
9	Fujitsu	2.2
10	Siemens	1.9

SOURCE: (Archbold, June 15, 1986, pp. 42-158)

TABLE 72: 1986 SOFTWARE MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	41.5
2	Unisys	6.5
3	DEC	4.2
4	NEC	3.8
5	Fujitsu	2.9
6	Siemens	2.9
7	Hewlett-Packard	2.8
8	Hitachi	2.5
9	Nixdorf	2.3
10	Lotus	2.1

SOURCE: (Datamation Staff, June 15, 1987, pp. 28-38)

TABLE 73: 1987 SOFTWARE MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	40.2
2	Unisys	6.8
3	DEC	4.1
4	NEC	4
5	Siemens	3.2
6	Fujitsu	3
7	Computer Associates	2.9
8	Hitachi	2.6
9	Hewlett-Packard	2.4
10	Nixdorf	2.4

SOURCE: (Runyan, June 15, 1988, pp. 155-166)

TABLE 74: 1988 SOFTWARE MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	38.5
2	NEC	4.3
3	Unisys	4.2
4	DEC	3.9
5	Computer Associates	3.4
6	Fujitsu	3.3
7	Siemens	3
8	Microsoft	3
9	Hitachi	2.9
10	Groupe Bull	2.6

SOURCE: (Braude, June 15, 1990, p. 160)

TABLE 75: 1989 SOFTWARE MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	34.3
2	Fujitsu	5.9
3	Computer Associates	5.2
4	NEC	4.3
5	Unisys	3.6
6	DEC	3.4
7	Microsoft	3.3
8	Hitachi	2.9
9	Siemens	2.6
10	Hewlett-Packard	2.4

SOURCE: (Poppell, June 15, 1990, p. 194-195)

TABLE 76: 1990 SOFTWARE MARKET SHARES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	FIRM	MARKET SHARE
1	IBM	30.1
2	Fujitsu	6.4
3	NEC	4.1
4	Microsoft	4
5	Computer Associates	4
6	Nixdorf	2.8
7	DEC	2.4
8	Hitachi	2.4
9	Oracle	2.1
10	Lotus	1.9

NOTE: Calculated from revenues in Datamation's top 1990 firms in North America, Europe, and Asia.

SOURCE: (Kelly, June 15, 1991, pp. 22-23)
(Appelton, July 1, 1991, pp. 60-64)
(Johnston, September 1, 1991, pp. 62-81)

TABLE 77: PURE SOFTWARE COMPANIES
TOP TEN FIRMS
BY MARKET SHARE PERCENTAGE

RANK	1989		1990	
1	Computer Assoc.	11.9	Microsoft	11
2	Microsoft	8.8	Computer Assoc.	9.8
3	Oracle	6.7	Oracle	7.7
4	Lotus	5.1	Lotus	5.1
5	D&B Software	4.2	D&B Software	4
6	Novell	3.9	Novell	3.7
7	Software AG	2.7	Wordperfect	3.4
8	McDonnell Douglas	2.7	Mentor Graphics	3.3
9	Wordperfect	2.6	Software AG	2.9
10	Bolt Bernek & Newman	2.2	Policy Mgmt Sys	2.6

SOURCE: (Hamilton, October 1, 1991, pp. 58-62)

TABLE 78: MICROCOMPUTER/SOFTWARE COMPARISON

COMPARISON IN CONSTANT 1990 DOLLARS

billions

1984 - 1990

YEAR	MICROCOMPUTERS	SOFTWARE DEVELOPMENT
1984	14.7	10.3
1985	18.5	13.9
1986	23	15.8
1987	27.1	19.6
1988	31.5	23.1
1989	39.3	25.8
1990	39	33.1

SOURCE: Revenues from the annual Datamation 100

TABLE 79: COMPUTER INDUSTRY ALLIANCES

AS OF JAN 92

DATE	ALLIANCE	FOCUS
Jul 1991	IBM/Apple	This is probably the strongest alliance with a primary intent of winning the desktop war of the 90s and decreasing Microsoft's strong hold on the PC software market. Joint efforts of the alliance include: research and development and the "Pink System," an advanced operating system that will marry the hardware of the two companies (Wall Street Journal Staff, September 26, 1991, p. B4)
1991	IBM/Novell	This alliance involves a two way exchange: IBM gets a LAN operating system; Novell gets access to IBM's corporate customer database (Coale, July 22, 1991, p. 45)
1991	IBM/ Borland	"Borland signs on to create C++ based tools to develop object-oriented programming languages for OS/2 and to add OjectVision to OS/2" (Coale, July 22, 1991, p. 45).
1991	IBM/ Mitsubishi Elec.	IBM agrees to sell computers to Mitsubishi who will seel them under the Mitsubishi name (Wall Street Journal Staff, August 6, 1991, p. A8).
Jun 1991	IBM/Lotus	IBM charms Lotus to develop critical E-mail API and groupware capabilities of Lotus' Notes into future releases of IBM's Office Vision and OS/2 (Freedman, July 1, 1991, p. 1).
Aug 1991	IBM/NEC	In a new U.S. strategy to sell parts to competitors, IBM negotiates the sale of mainframe disk drives to NEC (The Wall Street Journal Staff, August 6, 1991, p. A8).
Sept 1991	IBM/ Thinking Machines	The two firms reach a development agreement that will give IBM access to cutting-edge technology in massive parallel processing to strengthen IBM's push into the supercomputer market (Carroll, September 24, 1991, p. B4).

TABLE 80: COMPUTER INDUSTRY ALLIANCES

AS OF JAN 92

DATE	ALLIANCE	FOCUS
Dec 1991	**IBM/ Siemens**	IBM and Siemens in a joint venture develop their first production prototypes of computer memory chips that hold more than 64 million bits of information (Hooper, December 19, 1991, p. B4).
Jan 1992	**IBM/ Groupe Bull**	IBM purchases 5% in Groupe Bull and offers RISC chip technology (Hooper, January 29, 1992, p. A3).
1988	**Microsoft/ Sybase**	In a joint venture that once included Ashton-Tate, the two firms still remain on a project to develop an SQL server for OS/2 (Coale, July 22, 1991, p. 45).
Aug 1991	**Apple/Sony**	In a pact that worries IBM, "Sony agrees to produce protable personal computers for Apple Computer Inc., filling a major gap in Apple's product line." (Schlesinger, August 2, 1991, p. B3)
Sept 1991	**Siemens-Nixdorf/ Groupe Bull/ Olivetti**	Three of Europe's largest technology companies join forces to link the computer systems of Europe (Hooper, September 17, 1991, p. B4).
Sept 1991	**DEC/Intel/ Microsoft**	DEC quietly expands its strategic ties with Intel and Microsoft to play a larger role in the PC market. DEC also announces that its new worksation will use RISC technology to run Microsoft's Windows NT, allowing the workstation to run thousands of existing PC programs. (Wall Street Journal Staff, December 3, 1991, p. B3)
1991	**Toshiba/ Motorola**	The two firms agree to "a joint venture in Japan to manufacture memory and logic semiconductors." (Schlesinger, November 21, 1991, p. B3)

TABLE 81: COMPUTER INDUSTRY ALLIANCES
AS OF JAN 92

DATE	ALLIANCE	FOCUS
Oct 1991	IBM/Apple/ Motorola	The firms agree to exchange the technologies required for IBM to produce a Macintosh clone (Carroll, October 2, 1991, p. A3).
Oct 1991	Lotus/ Microsoft/ Phoenix	The firms announce a program to develop "a new class of protable 16 bit PCs smaller than a notebook." (The Wall Street Journal Staff, October 29, 1991, p. A24).
Nov 1991	Texas Instr./ Hitachi	The firms agree to "significantly broaden their alliance in memory semiconductors." (Schlesinger, November 21, 1991, p. B3).
Dec 1991	HP/Novell	The two firms reach a broad agreement to develop and market new computer networking technologies (yoder, December 11, 1991, p. B3).
Sept 1991	IBM/ Tata Group (India)	The Indian government gives IBM the go-ahead to manufacture personal computers and software in a joint venture with one of India's largest industrial conglomerates (Lachia, September 26, 1991, p. A8).
Oct 1991	Sequent/ Novell	The firms agree to deliver a file server "that can serve as many as 1000 users on a relational database." (Wall Street Journal Staff, October 15, 1991, p. B4).
1991	NEC/AT&T	The two firms agree to swap basic chip-making technologies (Schlesinger, November 21, 1991, p. B3).

TABLE 82: COMPUTER INDUSTRY ALLIANCES
AS OF JAN 92

------------------------ALLIANCES FOR STANDARDS------------------------

Apr 1988	**The "open systems" movement**	Sun, AT&T, and Unisys establish agreements focused on Sun's SPARC workstation line and AT&T's Unix operating system (Myers, July 5, 1991, p. 6B).
Fall 1988	**Open Systems Foundation (OSF)**	"DEC, Hewlett-Packard, IBM and others unite to develop an open Unix platform in response to AT&T's unwillingness to modify its Unix OS to their needs." (Coale, July 22, 1991, p. 45).
Apr 1991	**Advanced Computer Envir. (ACE)**	Led by Compaq, DEC, Microsoft, and Mips Computer Systems Inc. join forces to attempt to set standards for workstations. Mips provides the alliance with RISC chip technology (Myers, July 5, 1991, p. 6B).

TABLE 83: COMPUTER INDUSTRY CONSOLIDATIONS
AS OF JAN 92

DATE	FIRMS	FOCUS
1991	Novell/ Digital Research	The firms merge in an $80 million deal (Bremner, October 14, 1991, p. 87).
Jul 1991	Borland/ Ashton-Tate	In a common stock swap valued at $440 million Borland acquires Ashton-Tate (Coale, July 22, 1991, p. 45).
Aug 1991	Storage Tech./XL-Datacomp	Storage Technology, a maker of data-storage products primarily for mainframes, acquires XL/Datacomp, a distributor of IBM minicomputer systems and support services in a deal valued at $150 million (Blumenthal, August 6, 1991, p. B4).
Aug 1991	Computer Associates/ On-Line Software	CA purchases On-Line Software International Inc. for $120 million in its first big deal since acquiring Cullinet Software in 1989 (Carroll, August 19, 1991, p. B3).
Aug 1991	Knowledge-Ware/ Intellicorp	KnowledgeWare acquires Intellicorp in a stock swap valued at $34.1 million (Wall Street Journal Staff, August 27, 1991, p. B5).
Sept 1991	Computer Associates/ Pansophic	Stepping up its acquisition strategy, CA agrees to buy Pansophic Systems Inc. for $290 million (Fuchsberg, September 4, 1991, p. A5).
Sept 1991	Standard Microsys. /Western Digital	Standard Microsystems Corp. agrees to buy the local area network business of Western Digital for $33 million (Wall Street Journal Staff, September 18, 1991, p. B5).
Sept 1991	AT&T/NCR	AT&T acquires NCR in a computer manufacturing power move (Keller, December 3, 1991, p. A3).
Dec 1991	NCR/ Teradat	Barely two months after its acquisition by AT&T, NCR agrees to acquire Teradata in a stock swap valued at $520 million to get an expertise injection (Keller, December 3, 1991, p. A3).

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